ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 4, Issue 9, March 2015

Micro & Macro Watershed Management Using Remote Sensing and GIS Software for Talegaon Dabhade

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Abstract*— Watershed is not simply the hydrological unit but also socio-political-ecological entity which plays crucial role in determining food, social, and economical security and provides life support services to rural people. The criteria for selecting watershed size also depend on the objectives of the development and terrain slope. Conservation of natural resources is essential to sustain any developmental activity. Study area for this project is Talegaon Dabhade and Rural area around it, in Maval Taluka, Pune District of Maharashtra state. This area lies between latitude 18^{0}39'33'' N and 18^{0}43'71''N and Longitude 73^{0}45'02'' E and 73^{0}43'13'' E. It is about 120 km from Mumbai and 35 km from Pune. In this area drinking water demand is increasing day by day also there is fast growing industrial area which resulted in heavy ground water usage due to this ground water level is depleting by 0.2m per year. Soil erosion is also a major problem due to hilly area and heavy rainfall. First of all prioritization of watersheds is done for different watershed components so as to take any further relevant conservation measures. Availability of natural resources mainly land and water is studied using data from Central Ground Water Board, Indian Meteorological Department, Survey of India topo sheets and remote sensing data. Geographic Information System (GIS) based software is used for processing the topographic data of watershed. Based on this data various ground water recharge structures and water storage structures are suggested after doing benefit cost analysis.

***Index Terms*— GIS for watershed management, Micro and Macro watershed management, Water conservation techniques.**

I. INTRODUCTION

The rampant growth of population and advancements in life style have tremendously increased the demands for food, fuel, fodder, fiber, shelter, communication, etc. These growing demands are putting the resilience of the natural resource base under threat. To ensure food and water security, the vertical and horizontal expansion of production, has to be effective without degrading productivity. The rain fed agriculture contributes 58 per cent to world's food basket from 80 per cent agriculture lands (Raju et al. 2008). As a consequence of global population increase, water for food production is becoming an increasingly scarce resource, and the situation is further aggravated by climate change (Molden, 2007). The rain fed areas are the hotspots of poverty, malnutrition, food insecurity, prone to severe land degradation, water security and poor social and institutional infrastructure (Rockstorm et al. 2007; Wani et al. 2007).

Soil erosion and other forms of land degradation are causing problems for about 175 mha of land in India, which constitutes 53% of its total geographical area. Active erosion caused by water and winds alone accounts for 150 mha of land, which amounts to a loss of about 5,300 million tons of soil. In addition, 25 mha of land have been degraded due to ravines and gullies, shifting cultivation, salinity, alkalinity, waterlogging, and so on. Per capita arable land in India, which is around 0.17 ha at present, is expected to decrease to 0.09 ha by the year 2075 (Sebestian et al. 1995). In this context, soil and water conservation measures carried out on a watershed basis play a prominent role in the strategic task of achieving a comprehensive land and water management approach. Watershed management is the study of the relevant characteristics of a watershed, aimed at the sustainable distribution of its resources and the process of creating and implementing plans, programs and projects to sustain and enhance watershed functions that affect the plant, animal and human communities within a watershed boundary.

A. Watershed and It's Types

A watershed, also called a drainage basin or catchment area, is defined as an area in which all water flowing into it goes to a common outlet. People and livestock are the integral part of watershed and their activities affect the productive status of watersheds and vice versa.

Watershed could be classified into a number of groups depending upon the mode of classification. The common modes of categorization are the size, drainage, shape and land use pattern.

Table 1: Category of watershed based on area [10]

Sr. No.	Category of Hydrologic Units	Size Range (ha)	Average Size (ha)
1	Water Resource Region	270,00,000-1130,00,000	5,50,00,000
2	Basins	30,00,000-300,00,000	95,00,000
3	Catchments	10,00,000-50,00,000	30,00,000
4	Sub catchments	200,000-10,00,000	7,00,000
5	Watersheds	20,000-300,000	1,00,000
6	Sub watersheds	5,000-9,000	7,000
7	Micro watersheds	500-1,500	1,000

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The categorization could also base on the size of the stream or river the point of interception of the stream or the river and the drainage density and its distribution. The all India Soil and Land Use Surveys (AIS and LUS) of the ministry of Agriculture, Government of India, have developed a system for watershed dilation like water resource region, basin, catchments, sub-catchments, watersheds, sub watershed and micro watershed. The usually accepted seven levels of watershed dilation based on geological area of the watershed are given in Table 1

B. Objectives

a) Prioritization of micro watersheds and selecting the most severe one for micro watershed management.
b) To study the available natural resources mainly land and water.
c) To study the topography of micro watershed and obtain thematic information by using GIS and topo sheets of Survey of India.
d) To prepare the action plan for land resource development and water resource development

C. Study Area

Study area (Fig.1) for this project is located in Maval Taluka, Pune District of Maharashtra state. This area lies between latitude $18^{0}39^{'}33^{''}$ N and $18^{0}43^{'}71^{''}$N and Longitude $73^{0}45^{'}02$'' E and $73^{0}43^{'}13^{''}$ E. It is About 120 km from Mumbai and 35 km from Pune. Highest altitude in this area is 86.614m. It mainly includes Talegaon Dabhade city and Rural. Area of macro watershed is 102sq.km. Total population of study area as per 2011 census is 70,655.[13] Average annual rainfall is 1296 mm (1980- 2013).[12]

D. Need of Watershed Management for Talegaon Dabhade

1) Water demand

Total annual water demand for Talegaon Dabhade, Induri, Akurdi, Ambi and Nanoli based on forecasted population for year 2041 and considering domestic, industrial, public, institutional and commercial, and fire demand is 9302.78 million liter and total rainwater available is 78825.6 million liter. Considering approximate, 40 % losses due to evaporation, percolation we can store 47295.36 million liter rainwater. This shows that entire water requirement for study area can be satisfied by rainwater within the study area only.

2) Prevention of soil erosion

For preventing soil erosion velocity of surface water should be restricted. For this reason watershed management play a very important role. For example- Check dam, contour bunds etc.

3) Ground water recharge

Ground water level fall of 0.2m/year is observed in entire Maval taluka. Hence to avoid further ground water level fall ground water recharge is very important.

Fig.1: Study area

II. METHODOLOGY

Methodology adopted includes

A. Data Collection

- Topo sheets of No E43H9 and E43H10 are collected from Survey of India, Pune.
- Population data of project area is collected from reports of the Registrar General and Census Commissioner of India.
- Rainfall data of nearest rain gauge station (Vadgaon) is collected from Indian Metrological Department, Pune.
- Ground water data is taken from reports of Central Ground Water Board

B. Use of Software

Arc GIS is the latest software used for watershed management. Georeferencing of topo sheets is done using WGS 1984 coordinate system. By using Arc GIS software contour map (Fig.2) and drainage map (Fig.3) is prepared. These maps are further used for deciding the type and location of rainwater conservation system.

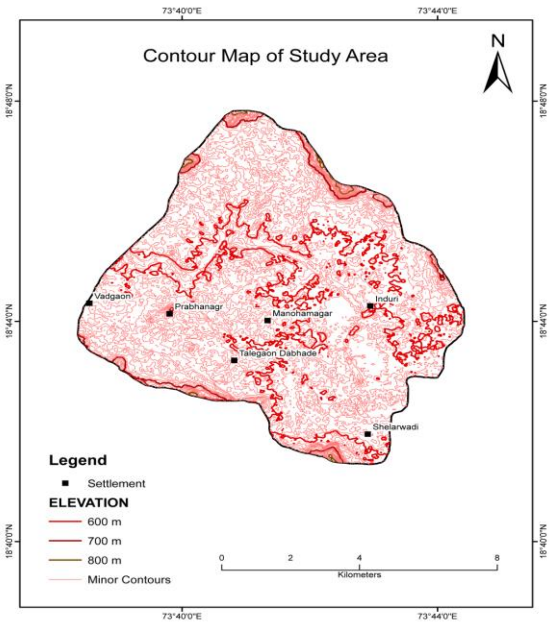

Fig.2: Contour map of study area

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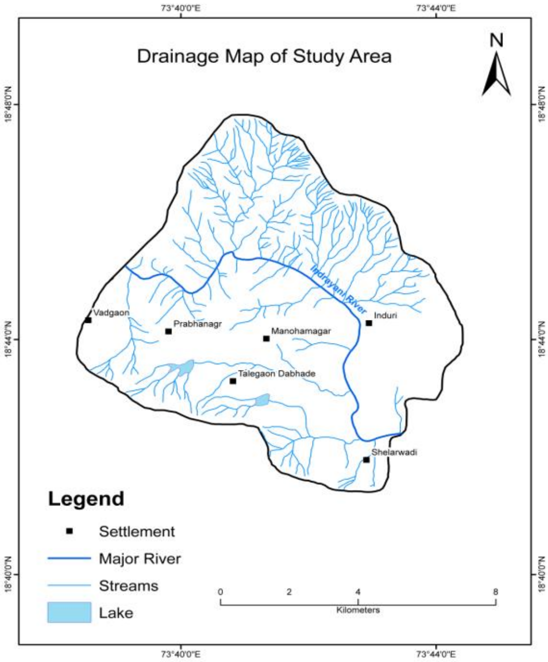

Fig.3: Drainage map of study area

III. PROPOSED WORKS IN STUDY AREA

A. *Surface Spreading Techniques*

These are aimed at increasing the contact area and residence time of surface water over the soil to enhance the infiltration. We have suggested this method to micro watersheds in Nanoli and Induri villages after considering following aspects,

- Gently sloping land without gullies or ridges.
- Surface soil is permeable and had high infiltration rate.
- Less chances of waterlogging.
- Aquifer material had moderate hydraulic conductivity so that the recharged water is retained for sufficiently long periods in the aquifer and can be used when needed.

Surface spreading techniques suggested for artificial recharge to ground water are flooding (Fig.4), ditch and furrows (Fig.5) and recharge basins.[2]

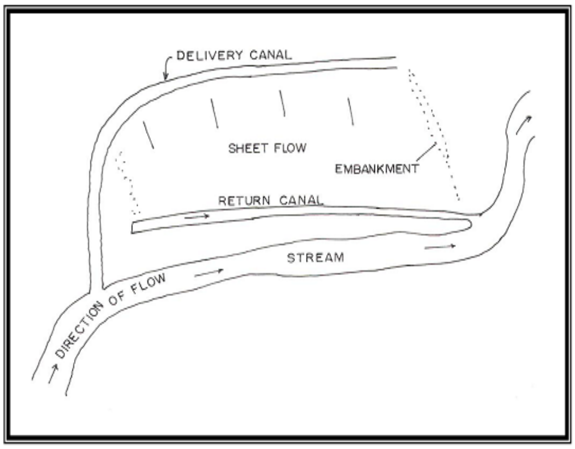

Fig.4: Schematics of typical flooding technique. [2]

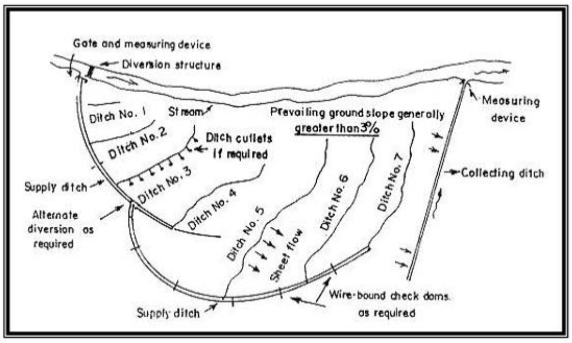

Fig.5: Schematics of typical ditch and furrow techniques [2]

B. *Runoff Conservation Structures*

These are normally multi-purpose measures, mutually complementary and conducive to soil and water conservation, afforestation and increased agricultural productivity. The structures commonly used are bench terracing, contour bunds, gully plugs, nalah bunds, check dams and percolation ponds.

1) *Bench terracing*

It involves leveling of sloping lands with surface gradients up to 8 percent and having adequate soil cover for bringing them under irrigation. It helps in soil conservation and holding runoff water on the terraced area for longer durations, leading to increased infiltration and ground water recharge. This method is suitable for surroundings of Ambi village.

2) *Contour bunds*

It is a watershed management practices aimed at building up soil moisture storage involve construction of small embankments or bunds across the slope of the land. They derive their names from the construction of bunds along contours of equal land elevation. This technique is generally adopted where gently sloping agricultural lands with very long slope lengths are available and the soils are permeable. These conditions are available in Ambi and Akurdi villages hence contour bunding is suggested here.

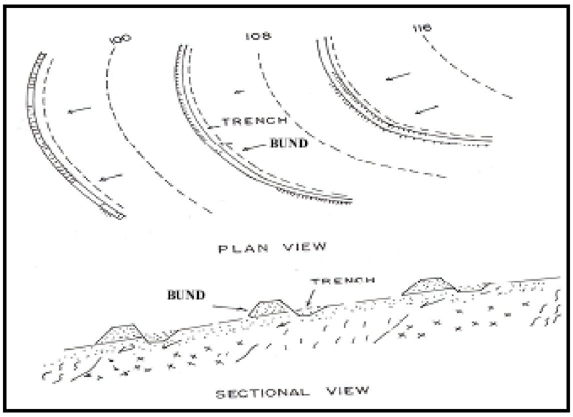

Fig.6: Schematics of typical contour bund [2]

3) *Gully Plugs, Nalah Bunds and Check Dams*

These structures are constructed across gullies, nalah or streams to check the flow of surface water in the stream channel and to retain water for longer durations in the pervious soil or rock surface. As compared to gully plugs,

ISSN: 2277-3754
ISO 9001:2008 Certified
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Volume 4, Issue 10, April 2015

which are normally constructed across first order streams, nalah bunds and check dams are constructed across bigger streams and in areas having gentler slopes. These may be temporary structures such as wooden block dams, loose / dry stone masonry check dams, Gabion check dams and woven wire dams constructed with locally available material or permanent structures constructed using stones, brick and cement.

The site selected for check dam should have sufficient thickness of permeable soils or weathered material to facilitate recharge of stored water within a short span of time. The water stored in these structures is mostly confined to the stream course and the height is normally less than 2 m. These are designed based on stream width and excess water is allowed to flow over the wall. In order to avoid scouring from excess runoff, water cushions are provided on the downstream side. To harness maximum runoff in the stream, a series of such check dams can be constructed to have recharge on a regional scale.

The following parameters are considered while selecting sites for check dams / nalah bunds:

- The total catchment area of the stream is between 40 and 100ha.
- The stream bed is 5 to 15 m wide and at least 1m deep.
- The soil downstream of the bund is not prone to waterlogging.
- The area downstream of the Check Dam / bund have irrigable land under well irrigation.
- The Check dams /Nalah bunds are preferably be located in areas where contour or graded bunding of lands have been carried out.
- Check dams / Nalah bunds suggested are 10 to 15 m long, 1 to 3 m wide and 2 to 3 m high, generally constructed in a trapezoidal form. Detailed studies are to be made in the watershed prior to construction of the check dam to assess the current erosion condition, land use and water balance.

For construction of the check dam, a trench, about 0.6 m wide in hard rock and l.2 m wide in soft impervious rock is dug for the foundation of core wall. A core brick cement wall, 0.6 m wide and raised at least 2.5m above the nalah bed is erected and the remaining portion of trench back filled on upstream side by impervious clay. The core wall is buttressed on both sides by a bund made up of local clays and stone pitching is done on the upstream face. If the bedrock is highly fractured, cement grouting is done to make the foundation leakage free.

For check dam construction three sites are selected two at the foot of Mangarul Hill and one in Nanoli village.

4) Percolation Tanks

Percolation tanks, which are based on principles similar to those on nalah bunds, are among the most common runoff harvesting structures in India. A percolation tank can be defined as an artificially created surface water body submerging a highly permeable land area so that the surface runoff is made to percolate and recharge the ground water storage. They differ from nalah bunds in having larger reservoir areas. They are not provided with sluices or outlets for discharging water from the tank for irrigation or other purposes. They may, however, be provided with arrangements for spilling away the surplus water that may enter the tank so as to avoid over-topping of the tank bund. It is possible to have more than one percolation tank in a catchment if sufficient surplus runoff is available and the site characteristics favour artificial recharge through such structures.

5) Modification of existing Tanks as Recharge Structures

Existing tanks which are silted and damaged, can be modified to serve as recharge structures. Unlike in the case of properly designed percolation tanks, cut-off trenches or waste weirs are not provided for these tanks. Desilting of tanks together with proper provision of waste weirs and cut off trenches on the upstream side can facilitate their use as recharge structures.

As such two tanks are available in study area they could be converted into cost effective structures for augmenting ground water recharge with minor modifications.

C. Roof Top Rainwater Harvesting

Among various techniques of rain water harvesting, harvesting rain water from roof tops is given special attention because of the following advantages:

a) Roof top rainwater harvesting is one of the appropriate options for augmenting ground water recharge/ storage in urban areas where natural recharge is considerably reduced due to increased urban activities and not much land is available for implementing any other artificial recharge measure. Roof top rainwater harvesting can supplement the domestic requirements in rural areas as well.
b) Rainwater runoff which otherwise flows through sewers and storm drains and is wasted, can be harvested and utilized.
c) Rainwater is bacteriologically safe, free from organic matter and is soft in nature.
d) It helps in reducing the frequent drainage congestion and flooding during heavy rains in urban areas where availability of open surfaces is limited and surface runoff is quite high.
e) It improves the quality of ground water through dilution.
f) The harnessed rainwater can be utilized at the time of need.
g) The structures required for harvesting rainwater are simple, economical and ecofriendly.
h) Roof catchments are relatively cleaner and free from contamination compared to the ground level catchments.
i) Losses from roof catchments are much less when compared to other catchments.

Collection of rainwater from roof tops for domestic needs is popular in some parts of India. The simplest method of roof top rainwater harvesting is the collection of rainwater in a large pot/vessel kept beneath the edge of the roof. The water thus collected can meet the immediate domestic needs. Tanks made of iron sheets, cement or bricks can also be used for storing water. In this method, water is collected from roofs using drain pipes / gutters fixed to roof edge.

Roof top rainwater harvesting should be made compulsory to industries in Talegaon Dabhade MIDC. Also physibility of roof top rainwater harvesting should be checked in all societies in Talegaon Dabhade.

IV. CONCLUSION

The aim of this project is to emphasize the importance of the water conservation and soil conservation to overcome from shortage of water and degradation of agricultural land. Due to GIS software it is possible to find out stream lines on which the structures are to be planned, slope direction, topography. The activities undertaken in this project include soil and water conservation measures like construction of ditch, furrows, recharge basins, bench terracing, contour bunds, gully plugs, nalah bunds, check dams and percolation ponds. Also there are some tanks which are not maintained properly. These can be converted to effective soil and water conservation structures with small investment. Roof top rainwater harvesting is a good mean to avoid wastage of rain water and choking of drains in rainy seasons.

If watershed development project implemented then it will result in improving the living standard and economic condition of people in Talegaon Dabhade and surrounding villages. For successful implementation of this project participation of local people, government officers and funding agencies is must. As these techniques are eco-friendly, the development due to this in future will be sustainable.

V. FURTHER SCOPE

Sites selected for various rainwater conservation structures are based on contour interval of 20 meter available in Topo sheets so for more accurate design detailed survey with Total Station should be done. Also detailed Benefit Cost analysis could be done for justifying rainwater conservation measures.

Environmental impact assessment should be done so that it could be helpful while implementing such schemes in other watersheds.

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