RESEARCH FRONT

ISSN
(Print) 2320 – 6446, (Online) 2320 – 8341

MICRO WATERSHED MANAGEMENT FOR AGRICULTURAL DEVELOPMENT IN SEMI ARID REGION: A STUDY FROM YERLA RIVER BASIN, MAHARASHTRA

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ABSTRACT

The Yerla River basin lies in the semi arid track of western Maharashtra. In this paper a study of Nimsod micro watershed is carried out to eradicate water scarcity for agricultural development of region. The objectives are to study morphometric parameters, land use and land cover classification and to identify suitable sites for watershed management structures using ridge to valley approach for agricultural development. For identification of suitable sites for various watershed management structures Toposheet, Google Earth images, rainfall data, GPS, ArcGIS software and technical watershed development guidelines of Soil Conservation and Agriculture Department, Govt. of Maharashtra are followed. Based on the field observations, LULC analysis, morphometric analysis and interpretation of maps have identified potential sites for 4 loose boulder structures, 8 contour trenches, 13 farm bunds, 6 farm ponds, 21 check dams and 1 percolation tank. In this micro watershed 48 structures are proposed through which it is estimated that 83 TCM water would be available. Proposed structures are useful to reduce soil erosion and recharge waterlevel, which are helpful for agricultural development of the region.

Key words: Micro watershed management, semi arid region, agricultural development, Nimsod, Yerla River basin, Maharashtra

INTRODUCTION

Water is indispensable for economic prosperity and overall development of a nation. Water resource is unevenly distributed on the surface of the earth. Under such conditions, coordination between demand and supply and different sources of water resources is imperative. The Nimsod micro watershed of Yerla River basin is located in the semi arid region of western Maharashtra, suffers throughout the year from acute water scarcity. In India due to absences of adequate storage facilities, about 37 percent of fresh water is drained to the sea. Therefore, it is evident that more than the availability of water; the challenges are related to collection, storage and management of available water (Jog et al., 2003). Watershed management techniques are useful to solve water scarcity in the drought prone regions. Proper treatment of micro watersheds provides a solution for meeting the frequent drought situations. The Government of India has been deploying considerable resources in different watershed development programmes since mid 1960s. Proper treatment of micro watersheds provides a solution for meeting the frequent drought situations (Tideman, 2007). Morphometric analysis of micro watershed is helpful to understand the drainage characteristics and geomorphology of area. Singh et al. (2014) and Telore and Unde (2017) stated that morphometric parameters are of immense utility in watershed prioritization for watershed management structures at micro-watershed level. Sreedevi et al (2004) stated that due to the implementation of proper watershed management model substantial reductions in

ISSN
(Print) 2320 – 6446, (Online) 2320 – 8341

runoff and soil loss, improvement in groundwater levels, improvement in land cover, increase in productivity and high incomes to the farmers in the Adarsha watershed in Kothapally of Ranga Reddy District, Andhra Pradesh. Ahaneku (2010) recommends home grown- soil and water conservation practices are vital to ameliorate the problems of soil degradation, erosion and water quality and stated that conservation of soil and water resources and its effective utilization as key to sustainable agricultural development in Nigeria. Karpuzcu and Delipinarl (2011) suggested that social, economical, environmental resource systems must be considered in order to improve the applicability of integrated watershed management approach. Rani (2016) and Telore (2016) stated that watershed development programmes are useful for the sustainable development of semi arid and arid regions. Saptarshi and Raghavendra (2009) and Telore and Unde (2016) carried out geoinformatics based evaluation of watersheds to ascertain site suitability for watershed management structures in various parts of India.

OBJECTIVES

To study land use and land cover classification of the study area. To carried out morphometric analysis of the study area and to identify suitable sites for watershed management structures for agricultural development in area using geospatial techniques.

STUDY AREA

Total geographical area of Nimsod micro watershed is 9.06 km^2. It is located on the right bank tributary in the mid west plateau region of the Yerla River basin between 17°26'13" E and 17°27'39" N latitudes and 74°25'08" E and 74°29'06" E longitudes (Figure 1). It lies 9 km west of Mayani village and 15 km south of Vaduj town. Vaduj is a headquarter of Khatav tahsil of Satara district. The area receives 552.72 mm average annual rainfall, which is also average rainfall of Vaduj and Khatav stations for the period of 1980 to 2012. Nimsod village is located in the downstream reaches of micro watershed. The area is facing acute water shortage almost throughout a year. Government of Maharashtra provides drinking water to the area by tankers from February to July months of every year (Plate 1A and B). The tributary flows from west to east and exhibits dendritic drainage pattern (Figure 3 B). Millets like sorghum and bajra, pulses, vegetables and fruits are cultivated prominently in the kharif season. The western part is benefitted by canal irrigation were cash crops like sugarcane, grape, pomegranate, chilly are cultivated. Scrub lands of western part is used for cattle grazing (Plate 1D). Details of the morphometric parameters are given in Table 1 and Table 2, LULC analysis in Table 3, details of watershed management structures and its estimated runoff in Table 4, details of cross sections are shown in Figure 2, various maps are shown in Figure 3A to H and photographs are shown in Plate 1A to D.

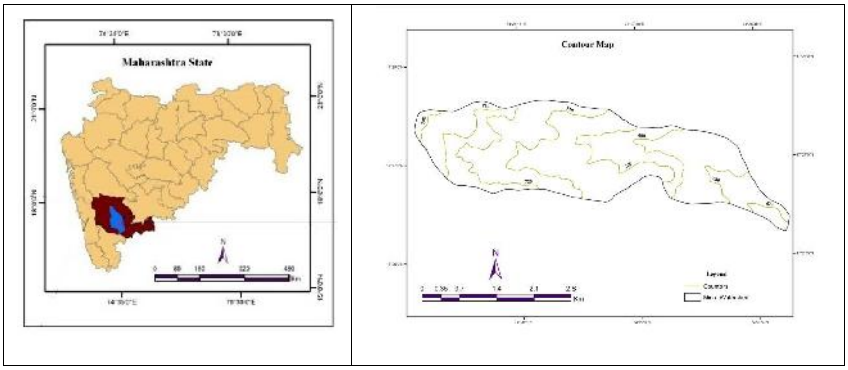


Figure 1 Location map

ISSN
(Print) 2320 – 6446, (Online) 2320 – 8341

MATERIALS AND METHODOLOGY

Survey of India toposheet no. 47 K/7 of 1:50,000 scale, IMD monthly rainfall data from 1980 to 2012, GPS, Google Earth Images, ArcGIS 9.3 software and technical watershed development guidelines of Soil Conservation and Agriculture Department, Govt. of Maharashtra are followed for identification of suitable sites for watershed management structures. Various thematic maps such as drainage map and stream ordering map, contour map, elevation map, slope map, aspect map, LULC map and DEM are prepared. Ground observation and checkup was made with the help of GPS during field visits. SOI toposheet of 1980 and Google Earth image of 2013 are used to study LULC classification. The morphometric parameters viz. stream ordering, stream length, bifurcation ratio, drainage density, stream frequency, relief ratio, elongation ratio and circularity ratio are calculated based on the formulas suggested by Horton (1945), Strahler (1964) and Miller (1953). Based on the field observations, morphometric analysis, land use and land cover analysis and interpretation of maps identifies potential sites for various watershed management structures for agricultural development the area.

RESULTS AND CONCLUSION:

Morphometric Analysis

Nimsod micro watershed is developed on third order tributary of the River Yerla. Drainage density and stream frequency values are 2.02 km/km^2 and 2.09 streams/km^2 respectively indicates coarse texture due to highly resistant sub-soil material and low relief. The calculated Millers form factor ratio of the study area is 0.17 suggests the elongated shape. Circularity ratio is 0.41 indicates elongated shape. Elongation value is 0.47 indicates less elongated shape. Compactness coefficient value of the area is 1.21 indicates less hazardous micro watershed. Length of overland flow is 0.25 km. Minimum and maximum values of height varies from 670 m to 740 m shows 70 m of moderate relative relief and 740m of absolute relief of the area (Figure 3G). The mean bifurcation ratio of the area low i.e. 1.87 which indicates that structure does not exercise a dominant influence of the drainage pattern. The area is characterised by an undulating topography with an average slope of about 0.96 percent. Slope of the area ranges between 0 and 5.50 degree of which 90 percent area lies below 1.40 degree (Figure 3C). Aspect map shows slope is towards east and north east, flat surface is common in the plateau area (Figure 3D). Plate 1C exhibits red boles of above 2.5 m thickness in the area. New wells are constructed in the micro watershed under MGNREGA Scheme in 2011 (Plate 1F). Figure 3A to H shows various maps of Nimsod micro watershed. Details of morphometric parameters are given in Table 1 and 2.

Slope (%)	Form Factor (Ff)	Circularity Ratio (Rc)	Elongation Ratio (Re)	Drainage Density (Dd)	Stream Frequency (km/km^2)	Compactness Coefficient (Cc)	Length of Overland flow (Lg)
0-5.50	0.17	0.41	0.47	2.02	2.09	1.21	0.25

Table 1: Morphometric parameters of Nimsod micro watershed - I

Basin Length (km)	Perimeter (P) (km)	Number of Streams			Stream Length (km) (Lu)			Mean Stream Length (km)	Bifurcation Ratio (Rb)			Mean Rb
		I	II	III	I	II	III		I	II	III	

ISSN
(Print) 2320 – 6446, (Online) 2320 – 8341

7.24	16.77	15	3	1	10.3	3.53	4.40	4.93	2.94	0.8		1.87

Table 2: Morphometric parameters of Nimsod micro watershed - II

Cross Section and Textural Analysis

Two cross profiles are taken from this plateau region micro watershed. First cross section is taken in the source region of mainstream which is 0.22 km from its source. The channel width and depth is 44.95 and 1.6 m and cross sectional area of profile is 71.92 m^2 (Figure 2, CS1). Both banks shows gentle slopes and clay-silt materials are commonly observed in this scrubland area. Second cross section is taken on eastern side first order tributary from 0.7 km from the source of mainstream in upper reaches. The channel width is 32.3 m and depth is 1.42 m and cross sectional area is 45.87 m^2 (Figure 2, CS2). The area is occupied by agricultural lands, so clay contents are observed.

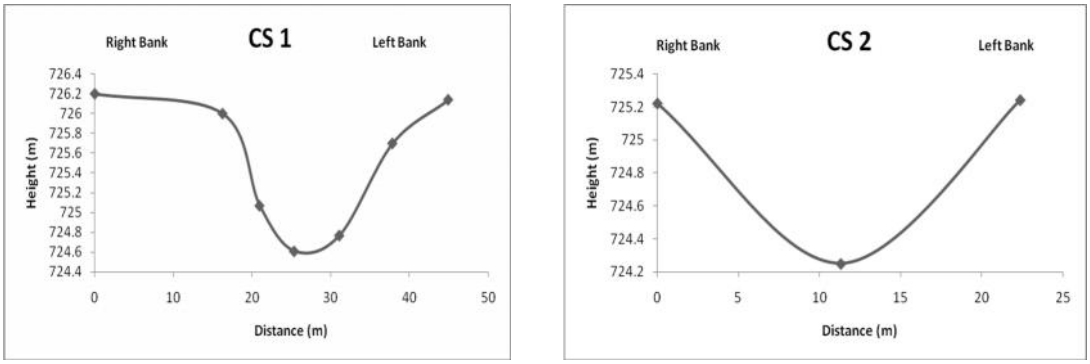


Figure 2 Cross section and sediment sample locations at Nimsod

Land use and Land cover Analysis

LULC analysis of Nimsod micro watershed is carried out using change detection method for 34 years. SOI toposheet of 1980 and Google Earth image of 2013 are used for the classification. LULC maps are presented in Figure 3 E and F. Six major categories are found including agriculture, vegetation, settlements, water bodies, canal and roads. Detailed statistics of each category is presented in Table 3. The result shows that the major change is the alteration of agriculture land to settlement. Based on the maps observation most significant changes are observed during this period that is expansion of settlement area by 0.88 % and its rate of change is 0.0021 km^2 per year. It is found that the sprawl of built up area encroaches area of agriculture and vegetation. Built up is area expand outward side. Canal is increased by 0.11% and its rate of change is 0.00029 km^2 per year. Vegetation cover is reduced by 0.77% and its rate of change is 0.0021 km^2 per year. Agricultural land is decreased by 0.22% and its rate of change is 0.0023 km^2 per year. No change is observed in water bodies, roads and reserved forest. Details of each LULC class and its rate of change is given in Table 3.

MW No.	Year	Land Use and Land Cover (Area in km^2)								Total Area (km^2)
		Agri-culture	Scrub land	Vegetation	Built up	Water bodies	Metalled Road	Forest	Canal	
Nimsod	1980	8.44		0.19	0.13	0.07	0.03	0.19	0.01	9.06
Area (%)		93.15	0	2.09	1.43	0.77	0.33	2.09	0.11	100
	2013	8.42		0.12	0.21	0.07	0.03	0.19	0.02	9.06
Area (%)		92.93	0	1.32	2.31	0.77	0.33	2.09	0.22	100
Total Change		-.22	0	-0.77	0.88	0	0	0	0.11	0

ISSN
(Print) 2320 – 6446, (Online) 2320 – 8341

(%)									
Rate of Change (km^2/year)	-.0006	0	-0.002	0.002	0	0	0	.0002	

Table 3 Land use and land cover class and its rate of change

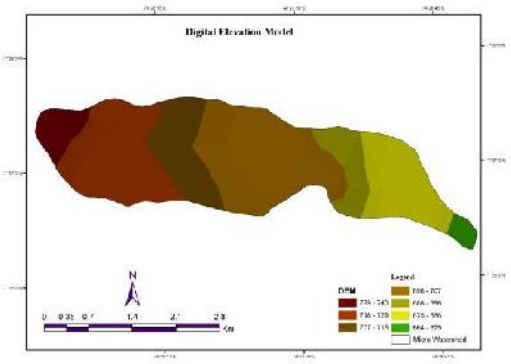
Watershed Management Structures

In the Nimsod micro watershed six structures are proposed based on different criterias following ridge to valley approach (Figure 3 H). In the micro watershed 4 loose boulder structures are proposed in the upper reaches to reduce gully erosion on first order streams. 8 contour trenches and 13 farm bunds are proposed in the upper reaches to reduce soil erosion and recharge sub surface water level. 6 farm ponds are suggested in the middle reaches in soils of less percolation. 21 check dams are proposed in the middle and lower reaches on first to third order streams. One percolation tank is proposed on the third order stream in soils which prevent water logging in middle reaches (Figure 3 H, Table 4). In this micro watershed 48 structures are proposed due to which it is estimated that 83 TCM water would be available. Proposed structures are helpful to reduce soil erosion and recharge waterlevel. Details of watershed management structure and estimated water runoff are given in Table 4.

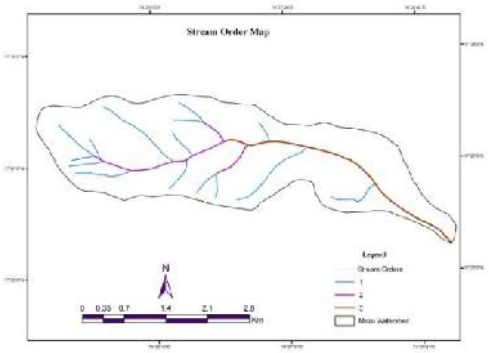
Micro Watershed and Estimated Runoff (TCM)	**Number of Watershed Management Structures**												**Total Estimated Runoff (TCM)**		**Total Estimated Runoff (TCM)**
	LBS	**LBS**	**CT**	**CT**	**FB**	**FB**	**FP**	**FP**	**CD**	**CD**	**PT**	**PT**			
	E	**P**	**E**	**P**	**E**	**P**	**E**	**P**	**E**	**P**	**E**	**P**	**E**	**P**	
Nimsod	5	4	5	8	5	13	5	6	12	21	1	1	33	**53**	86
Estimated Runoff							3.5	4.2	36	63	20	20	59.5	**87.2**	146.7

LBS: Loose boulder structure**, CT:** Contour Trench**, FB:** Farm Bund**, FP:** Farm Pond**, CD:** Check Dam**, PT:** Percolation Tank **E**: Existing, **P** : Proposed

Table 4 Details of watershed management structures and its estimated runoff (TCM)

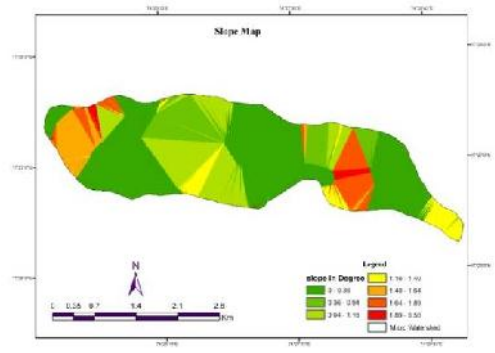


A. Digital Elevation Model

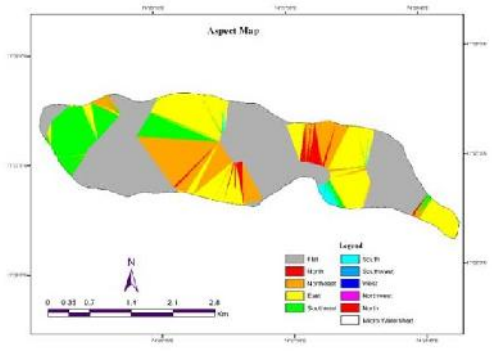


B. Drainage and Stream Ordering Map

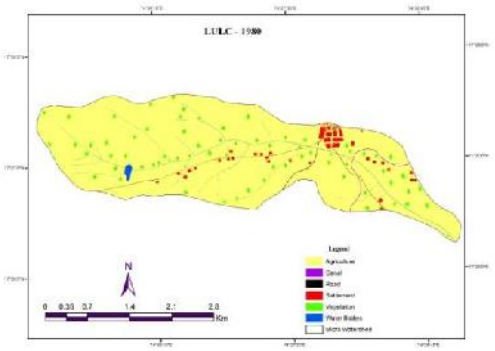
ISSN
(Print) 2320 – 6446, (Online) 2320 – 8341



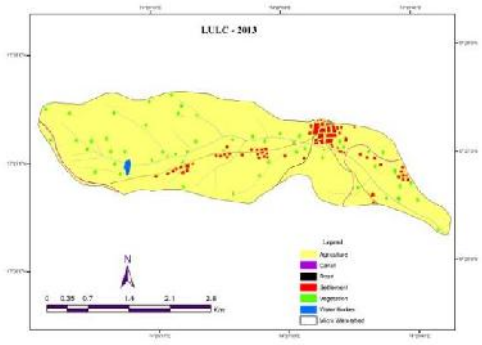
C. Slope map



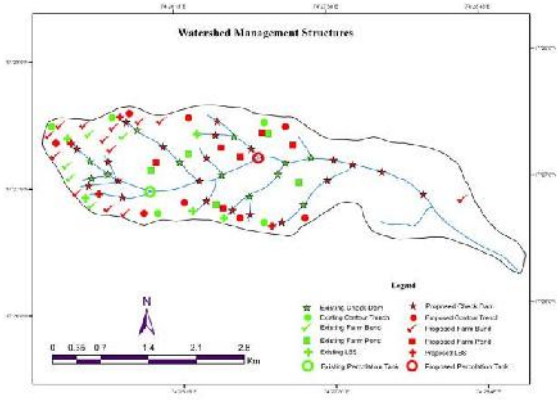
D. Aspect map



E. Land use and Land cover map 1980



F. Land use and Land cover map 2013



H. Watershed management structures

Figure 3 Various maps of Nimsod micro watershed

ISSN
(Print) 2320 – 6446, (Online) 2320 – 8341

A. Well used to store tank water

B. Barrels to store water in summer

C. Red bole of 2.5 m thickness

D. Field observations to suggest suitable sites for conservation

E. Existing cement check dam in the middle reaches

F. A well constructed under MGNREGA in 2011

Plate 1 Photographs of Nimsod micro watershed

CONCLUSION

In the semi arid Nimsod micro watershed on the basis of field observations, LULC analysis, morphometric analysis and interpretation of maps identified potential sites for loose boulder structures, contour trenches, farm ponds, check dams, percolation tanks are proposed. In this area 36 structures are proposed due to which it is estimated about 56.3 TCM water would be available. Proposed watershed management structures are helpful to reduce soil erosion and recharge waterlevel in this semi arid micro watershed. It will reduce water scarcity and provide water for agricultural production in Kharif and Rabbi seasons. Present study shows that micro watershed management is useful tool for agricultural development of the region.

Acknowledgements: First author is thankful to Dr. S.R. Bamane, Principal, R.S.B Mahavidyalaya, Aundh, Satara for encouragement and Dr. M.G. Unde, Professor and Head, Dept. of Geography, Ahmednagar College, Ahmednagar for critical assessment of the work.

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