Integrated Spatial Assessment of Land and Water Resources in Watershed for Sustainable Growth

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***Abstract*—The watershed wise integrated planning of the area through spatial evaluation using different process models will result in generation of suitable action plans for diverse vegetative growth in the area leading to sustainable development. The development of micro- watersheds as a result of suggested treatment over a period of time can lead to positive changes in landscapes as indicated by multi- temporal satellite data and field visits. The diversity in the vegetation growth attributed to the integrated planning and suggestive action plans such as creation of infrastructures for conservation, drainage line treatment, people's participation and live stack improvement can result in improvement in diversification of crops as shown by values of saturation index, fragmentation, terrain complexity, biological richness and Simpson's index obtained from sample plots of the area. The details of the same are given in the paper**

Keywords—Sustainable development

INTRODUCTION

The integrated spatial assessment of land and water resources of watersheds involve integration of surface and ground resources of river basin with an objective of evaluating for water availability and demand from the watershed. This will facilitate planning for alternative farming system, reclamation of wasteland, and erosion control and land development in the area.

Thus, blending of remote sensing and GIS technologies has proved to be an efficient tool and have been successfully used by various investigators for water resources development and management projects as well as for watershed characterization and prioritization . Accordingly there is an expectation of productive transformation of treated micro watersheds in the area. The spatial assessments of micro watersheds will evaluate crop diversity of the area indicated by using different diversity indices utilized for diversity evaluation.

A few more studies are reported where remotely sensed data had been used for the assessment of soil degradation to devise cost effective methods for soil conservation . The integrated watershed management and the suggested line of treatment for the area will enable diverse growth in the area based upon the water availability.

Watershed development program is, therefore, considered as an effective tool for addressing many of these problems and recognized as potential engine for agriculture growth and development in fragile and marginal rain-fed areas .Management of natural resources at watershed scale produces multiple bene1ts in terms of increasing food production, improving livelihoods, protecting environment, addressing gender and equity issues along with biodiversity concerns .The water availability in the water shed can be computed as dependability yield for a specified risk percentage using the rainfall records of the area. This will facilitate capacity determination of water conservation structures and computation of the water demand can be computed by summing up different water uses in the area

STUDY AREA

The study area chosen for integrated spatial assessment covers different micro watersheds and lie between 73°44’ 50” to 73°49’ 1” longitudes and 18°30’ to 18°33’ 58” latitudes comprising of nine micro watersheds near Mulshi area of Pune district with a spread area equals 55.2 KM^2. The conservation measures for development of every micro watershed have been suggested and carried out in these micro watersheds having well distributed streams Fig 1 shows the study area, which constitute as a large watershed and divided into nine micro watersheds. The annual rainfall data was collected from 2005 to 2015 for the area to compute the dependability yield at risk percentage of 60%. The crop grown in the area has root zone depth varying from 20 to 50 cms and the soil bulk density is varying from 1.28 to 1.59 gram/c.c with field capacity of soil being 0.13 and evapotranspiration in summer and winter varying from 157 to 165 cms. The annual rainfall for the area varied from 460 mm to 1152 mm for the 11 years data collected and the water availability for the micro watersheds as dependability yield at 60% risk has been worked out to 842 mm excluding the different losses.

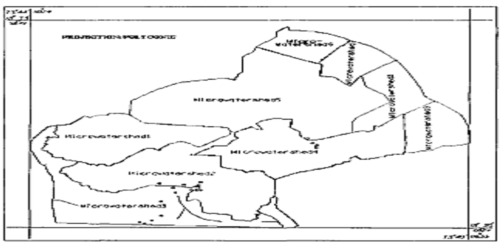

FIG-1: MICRO WATERSHEDS OF THE STUDY

III. METHODOLOGY

Spatial integrated Watershed Management carried out earlier in the area had suggested activities such as creation of infrastructure for water and soil conservation, conservation measures in arable and non arable lands, drainage line treatment, line stock development and people's participation. The development activities were carried out over a period of 5 years in between 2014 to 2018and the actual number of units developed for different purpose during the period was compared with the total number of units in the area for the nine micro watersheds suggested for development. This data was utilized to calculate the saturation index as an index for development in the area attributed to integrated spatial study

The crop diversity in the agricultural command was assessed by applying different indices of diversity seen as a measure of development for studying crop diversity using thedata from four well distributed sample area chosen in the area. The crop samples and sample area were studied for number of species, number of crops and terrain ruggedness to determine the factors such as fragmentation, porosity, biological richness and Simpson's diversity index.The Fragmentation is the sum of total species present in the sample size x Number of each species divided by the sample area. The porosity is indicated as the total number of crops of all species. The biological richness is weighted sum of fragmentation, porosity and terrain ruggedness number with sum of the weights equal to one. The Simpson's Diversity Index (D) is given by an equation (1- Σ $n_i(n_i-1)$)/N(N-1) inwhich n_i is given by number of individual of species ' i ' , N = Total number of individuals of all species. All the above biological indices were determined by collecting four well distributed samples in the area. The samples were utilized for computing the different indices used as parameters for ascertaining the diversity for the area. The land cover changes were brought out using multi-date Remote sensing data of 5.6 m spatial resolution to compute the saturation index for every watershed as a measure of development in the watershed.Where n_i is given by number of individual of species ' i ' , N = Total number of individuals of all species. All the above biological indices were determined by collecting four well distributed samples in the area. The samples were utilized for computing the different indices used as parameters for ascertaining the diversity for the area. The land cover changes were brought out using multi-date Remote sensing data of 5.6 m spatial resolution to compute the saturation index for every watershed as a measure of development in the watershed

IV. RESULTS AND DISCUSSIONS

The dependability yield to indicate the water availability forthe watershed area was obtained from the annual rainfall data arranged in the descending order of their magnitude for ensuring planning of water conservation capacities for different water uses. The ranking of the rainfall for the data is shown as six and the corresponding rainfall value is 842 mm for 60% risk. The dependability volume accordingly for the catchment area of 55.2 KM^2 will be 46.4 Million cubic metre for which 10% evaporation and 15% conveyance loss will have to be added. The land use and land cover transformation as a change in the micro watershed area are attributed to implementation of appropriate suggested micro watershed treatment carried out between periods 2014 to 2018 and observed through multi temporal high resolution satellite data including field visits along with computation of Saturation Index values. The details of which are shown in Table-I. More the changes shown in the area can be indicative of higher saturation index. It is seen that there is a reduction in fallow land, waste land and dense forest area; however there is an increase in agricultural area, water bodies, and plantation with total performance percentage varying from 8.55% to 27.76%.The saturation index calculation for the micro watersheds is shown in Table-II for the area. The variation of saturation index for the different criteria of development of micro watersheds was from 57.8 % to 68.14 % indicating moderate to high sustainable growth for the area. The biological condition in the area were determined by applying aforesaid different indices on the four sample data each of size 100 m x100 m and are presented in the Table-III and Table-IV. The values of the indices suggest a reasonable diversity for the region attributed to the suggested integrated spatial action plans for the watersheds. The suggested watershed management action plan executed through a concerted effort has brought a change that has increased the biological diversity of the region.

V. CONCLUSION

The success of integrated spatial assessment and development program for watershed requires appropriate technical and managerial measures with people's participation in the entire project. The benefits of soil and water conservation will be achieved by proper planning with community managementbuilt on existing social structure along with project management drawn from village level organizations. This can lead to sustainable economic development with improvedliving condition. The participation of community can improve ecological balance attained through cost affordable technics for easy acceptance. The suggested watershed management plans can bring value additions leading to improved biological diversity and change of landscapes as indicated in the multi temporal remote sensing images and computed values of diversity indices.

Table 1: VALUES OF SATURATION INDEX AND CHANGES IN LAND-COVER (%) FOR THE AREA

Sl.No	Moist Fallow(%)	Dry Fallow(%)	Agri	Water Body(%)	Plantation(%)	Wasteland (%)	Dense Veg(%)	Total Performance%	Saturation Index
1	-10	-15.3	23.6	1.76	2.4	-2.16	-2.48	27.76	62.16
2	-8.5	-14.6	20.4	1.85	2.24	-2.24	-2.35	24.49	57.8
3	-6.6	-10.1	5.3	2.5	2.8	-2.5	-1.65	10.6	65.66
4	-7.8	-6.2	7.8	5.6	1.48	-2.1	-1.46	14.88	68.14
5	-7.9	-7.5	7.66	5.4	2.2	-1.8	-1.88	15.26	63.24
6	-6.9	-6.7	6.6	4.8	2.4	-1.9	-2.12	13.10	58.15
7	8.8%	-7.1	7.8	5.1	3.5	-2.2	-1.92	16.56	61.23
8	-5.1	-4.8	3.5	3.8	1.6	-1.3%	-1.11	8.55	66.26
9	-5.2	-4.6	3.4	3.7	1.4	-1.1%	-1.31	8.6	63.18

Table 2 METHODOLOGY FOR COMPUTING SATURATION INDEX

Details of Activity for Devpt	Total Units for	Actual Units Devpd in WS	Total Marks Assigned	Actual Marks (Col3/col2) *Col 4
Construction Of Infrastructure	62	45	30	21.77
Conservation Measure in Arable and Non arable lands.	62	38	25	15.32
Drainage Line Treatment	62	31	10	05
Livestock Development	62	35	15	8.46
Peoples Participation	62	36	20	11.61
Total			100	62.16

Sample No	No- Of Crop -1 Species	No of Crop-2 Species	No Of Crop-3 Species	No Crop-4 Species	No Crop-5 Species	No Crop-6 Species	Total Crop in Sample	Total all species in sample	Sample Area sq m	Simpson's Index
1	42	32	38	42	46	37	6	237	10^3	0.969
2	35	33	33	37	41	31	6	210	10^3	0.972
3	49	51	39	47	45	Nil	5	231	10^3	0.955
4	48	47	38	41	43	Nil	5	217	10^3	0.951

TABLE-III: COMPUTATION OF DIVERSITY INDEX FOR SAMPLE AREA

Sample No	No of Crops	No of Species	Sample Area--m2	Fragmentation	Terrain Complexity	Biological Richness
1	6	237	1000	0.14	2.64	897.78
2	6	210	1000	0.126	1.46	896.58
3	5	231	1000	0.115	1.82	896.93
4	5	217	1000	0.108	1.61	896.71
	Porosity	895				

TABLE-IV: CROP DIVERSITY FOR THE FOUR SAMPLE PLOTS

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