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EVALUATION OF THE BEST MANAGEMENT PRACTICES USING SWAT MODEL FOR THE KANERI MICRO-WATERSHED, SOUTHERN MAHARASHTRA, INDIA

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ABSTRACT

In spite of sufficient rainfall, rural people in some areas of our country have to depend upon tankers even for their domestic water supply in summers. But by having soil and land management along with water management thus developing the watersheds, overall development of rural area is possible, which will solve the problem of water scarcity[1]. For assessing the impact of land management practices and climate on water flow and sediment yield in ungauged Kaneri watershed, SWAT (Soil and Water Assessment Tool) Model was used in the study. The simulations were carried out for different scenarios. Simulations suggested that, due to provision of BMPs like very simple techniques, as farm ponds, contour trenches, gulley plugging, terrace bunding the surface runoff may decrease in the range of 62 % to 75% .This will result in nearly doubling the percolation, decreasing water yield in the range of 33% to 53 % and reducing sediment yield by nearly 98%. By comparing the results of simulations, it is found that the provision of farm ponds in each sub basin of watershed gives better results than other BMPs. If more such farm ponds are provided in the watershed, it will certainly save tonnes of soil loss from erosion as well as will increase the water availability in the watershed, making the village people self sustained in water needs .

Keywords - BMP(Best Management Practices), Digital Elevation Model, Scenario, SWAT Model, Swat Simulations

I .INTRODUCTION

Watershed management is the revolutionary programme designed for the water scarce areas , aimed mainly at giving the work to the idle hands of the farmers in the seasons other than monsoon[2]. The challenge, in present situation is to improve rural livelihoods through efficient and sustainable rainwater management technologies for increasing rain-fed productivity and thereby contribute to food and livelihood security[3]. Watershed management techniques include very simple structures like Farm Pond[4] , Percolation Tank [5],Check Dams[6], Contour Trenches etc[7]. The core theme of the model is sustainable natural resource management for increasing the farm productivity and improving the rural livelihoods. [8]. Watersheds suffer from the soil erosion problem severely, depending upon the topographical features of the terrain and watershed[2]. SWAT was selected to model the hydrological processes and compute runoff, water yield, sediment yield, Evapo transpiration, potential Evapo transpiration, soil moisture, lateral flow and ground water flow from the Kaneri watershed.

II. METHODS AND MATERIALS

The objectives of the present study will be achieved by following methodology.

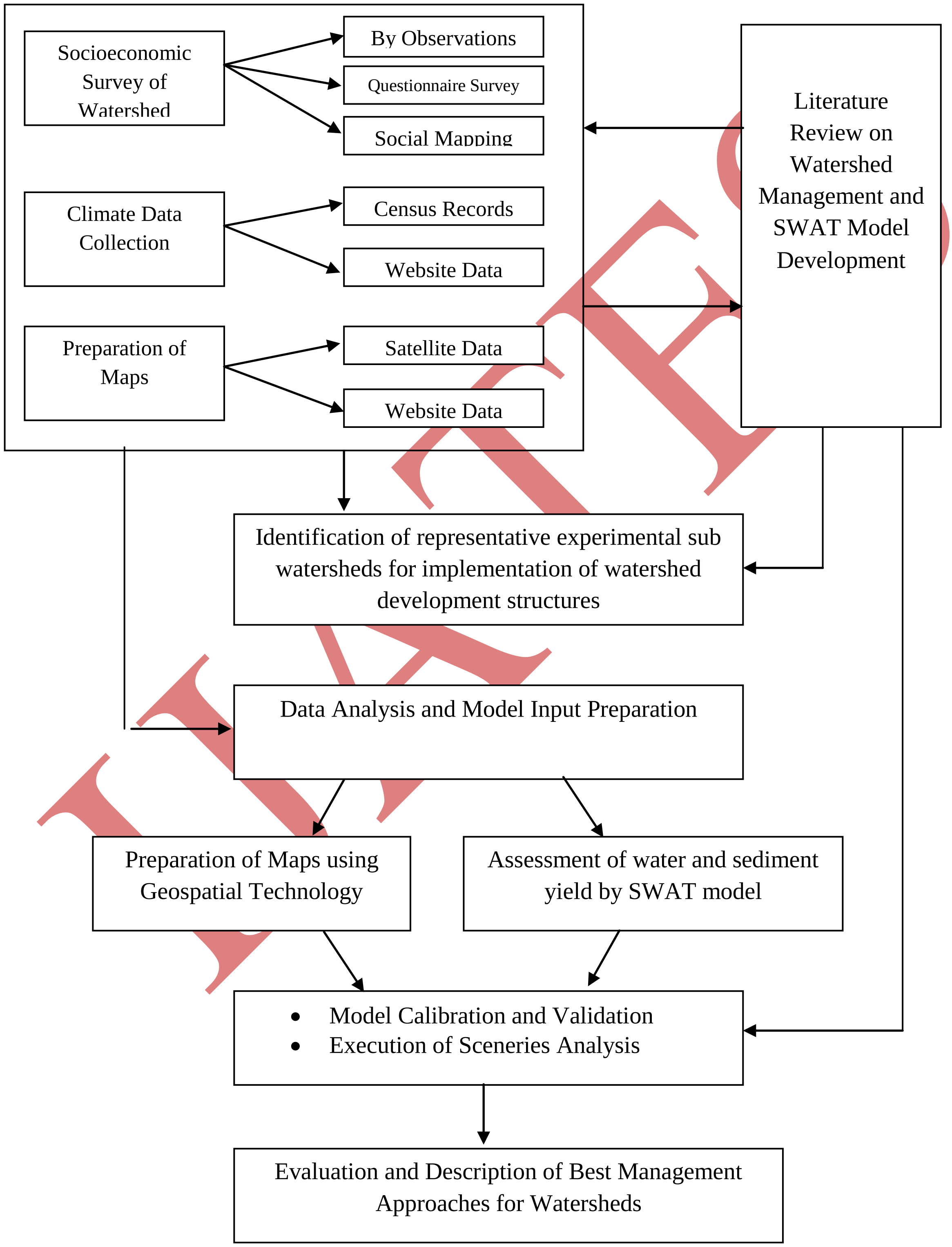

Fig. 1 Summary of Methodological Approach to Develop a SWAT Model

III. STUDY AREA

Kaneri watershed is located in south Maharashtra region and is dominated by undulating plateau. It is located on the south-East part of Kolhapur city on pune - Bangalore highway in Maharashtra state. It is located at 16.6055 and 16.6412 N and 74.2535 and 74.2906 E and 11 kms away from Kolhapur. It is surrounded by small Hills. Geographical area of the village is 870.38 hectares. Watershed lies in extreme elevation variation from 600 m. to 690 m. The village falls in agro-climatic zone IV and characterized by rainfall ranging from 800 to 1000 mm. The main occupation of the village is agriculture as about 70% of work force of the village is engaged in agriculture work. Watershed is facing average soil loss of 11.172 T/Ha every year. Figure 2 shows Google Earth image of Kaneri watershed and Figure 3 shows its land use distribution .

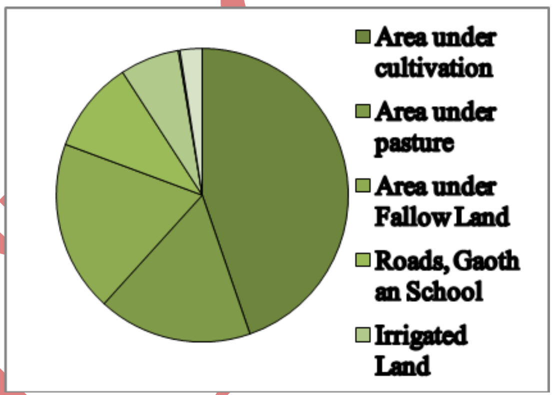

Fig.2-GE Image of Kaneri Watershed **Fig.3 Land use distribution of Kaneri**

Soils available in Kaneri Watershed are mainly of three types -Silty Clay Loam , Clay Loam and Silty Loam. [9] The main objective of the present study is to evaluate the best management practices for the Kaneri watershed for soil and water conservation so that the water after proper conservation will be sufficient for fulfilling needs of the village people.

IV. INPUT DATA AND SWAT MODEL SET UP

For Model development the spatial data was needed ,which was prepared by using geospatial technology. Open Source Tool Quantum GIS 2.2.0 was used for preparation of maps and Arc GIS 10.1 was used for modeling the watershed.

A 30 m by 30 m resolution ASTERDEM was derived and re sampled to 15m X 15m for ease in data acquisition. Sub basin parameters such as slope gradient, slope length of terrain and the stream network characteristics such as channel length, width and slope were calculated and used by the model. A map of land use was created by recording the crop type on each plot in the watershed and by identifying the land cover on areas other than cultivated fields. Google image of the watershed exactly fits and represents all fields in the watershed. Hence, the image was used for recording. LULC map was acquired from LISS III (Linear Imaging and Self Scanning Sensors).The digital Google image was geo-referenced by taking control points around and inside the watershed. The shape file representing each plot and other land covers was created using the digitizing tools provided in ArcGIS, ArcMap.

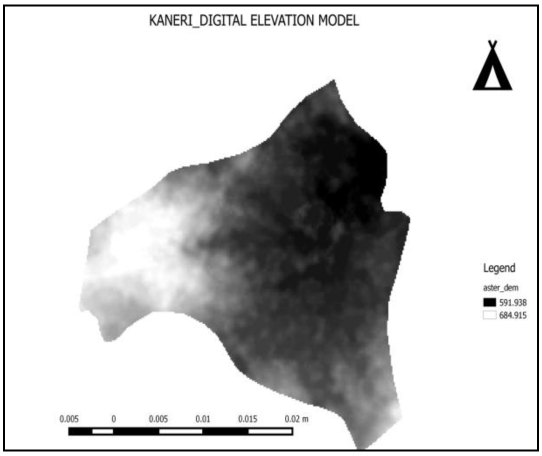

Fig. 4 Digital Elevation Model of Kaneri

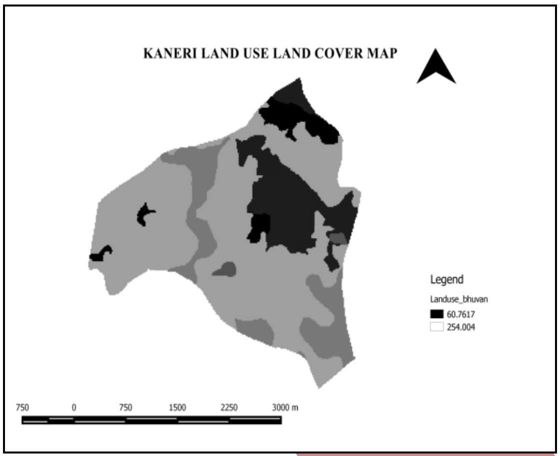

Fig.5 LULC Map of Kaneri Watershed

The final soil map of Kaneri Watershed was prepared by referring the data collected from the soil sample survey report and using soil map of Maharashtra acquired from NBSS and LUP, Nagpur for digitization. Figure shows the soil map of Kaneri Watershed.

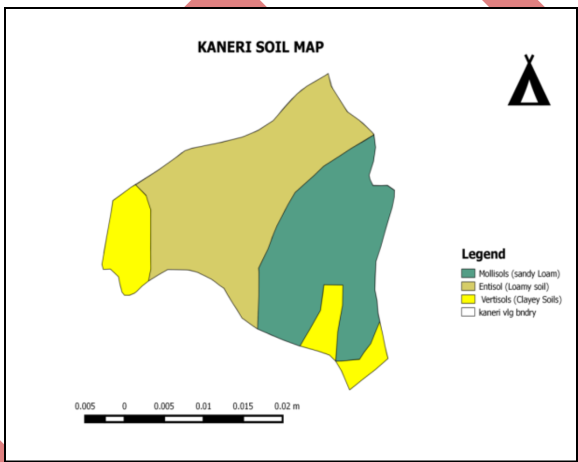

Fig.6 Soil Map of Kaneri Watershed

SWAT requires daily or sub-daily meteorological data[10]. In this study, measured meteorological data were used and the weather generator model was set up to estimate any missing data. The meteorological data used were daily precipitation and daily maximum and minimum air temperature. The data from January 1979 – July 2014 were obtained from the website www.swattamu.edu.[11]

For watershed delineation and for preparing maps needed for modeling, open source GIS tool - Quantum GIS was used. The watershed outlet was manually added and selected for finalizing the watershed delineation. With this information the model automatically delineated a watershed of 536 ha and 28 sub basins were produced. Multiple HRUs were defined within a sub basin by ignoring land uses less than 2% of the subbasin and also ignoring soil types in a subbasin covering less than 5% of the subbasin. A total of 86 HRUs for 28 sub basins were created.

V. MODEL CALBRATION AND VALIDATION FOR WATER FLOW AND SEDIMENT YIELD

Flow and sediment calibration for the Kaneri watershed was conducted for the years 1979 to 2013. Likewise, flow and sediment validation for the Kaneri watershed was carried out for the years 2001 to 2013. Initially, the model was calibrated on an annual basis. The surface runoff and total sediment yield were calibrated first. The model goodness-of-fit was evaluated both on a monthly and on a yearly basis as shown in Tables 1 and 2.

Table 1 Coefficient of determination and the Nash – Sutcliffe Coefficients for calibration and validation on yearly basis

	CALIBRATION		VALIDATION	
	R 2	NSE	R 2	NSE
FLOW	0.564	0.56	0.950	0.929
SEDIMENT	0.731	0.73	0.684	0.66

Table 2 Coefficient of determination and the Nash – Sutcliffe Coefficients for calibration and validation on monthly basis

	CALIBRATION		VALIDATION	
	R 2	NSE	R 2	NSE
FLOW	0.835	0.835	0.801	0.12
SEDIMENT	0.663	0.663	0.565	0.639

VI. SWAT SIMULATIONS - RESULTS AND DISCUSSIONS

Simulation was done for the model run with some appropriate scenarios for different sub basins. The results from both the results were compared. The scenarios considered were the best management practices proved to be appropriate with low costs and easy in construction. SWAT model was run for 20 years i.e. from 1991 to 2010.The output for four simulaions was tabulated. The results for last four years of simulation were compiled for interpretation of impact of watershed management structures on flow and sediment yield. Initially in the base scenario, the sediment yield was 35.95 Ton/Ha/Year and surface runoff was 172.08mm. The percolation was found to be 9.92% of the total precipitation and ground water contribution was 7.49%. Table shows the output of the simulations in different scenarios and their comparative statements.

In second scenario , the flow was calibrated using the sensitive parameters to improve the objective functions (R2 and NSE). The base flow recession constant (the baseflow alpha factor (ALPHA_BF was adjusted to 0.2. The groundwater "revap" coefficient (GW_REVAP) which controls the rate of transfer of water from the shallow aquifer to the root zones was adjusted to 0.2. The threshold depth of water in mm in the shallow aquifer for "revap" or percolation to the deep aquifer to occur (REVAPMN), the soil evaporation coefficient (ESCO), and the plant uptake compensation factor (EPCO) were adjusted to 0.001, 0.8 and 0.9 respectively. The parameters were changed and the impact on hydrological processes was studied.

In third scenario, each sub basin was provided with the pond and the impact was studied. Figure shows the graph representing the corresponding changes .

In fourth scenario, the best management practices were provided as per the soils, land use and topography of the areas and the impact was studied. These BMPs include Farm terracing, Contouring, Residue management and Generic conservation practices [12]and the impact was studied. Table 3 gives the respective results of simulations. It also gives comparative study of impact of different scenarios on watershed .

Table 3 Output of the simulations and their impact on hydrological processes

Year	Simulation	Qsurf	Qlat	Qgw	Perc	SW	ET	Wat.YLD	Sed.YLD	Prec.
2007	SIM1	172.08	10.39	57.81	76.59	169.77	565.17	246.53	35.95	771.31
	SIM2	166.99	9.48		65.31	150.72	586.26	181.89	35.94	771.31
	SIM3		1.9	56.93				103.72	7.26	771.31
	SIM4	60.12	3.46	137.79	159.38	152.09	591.06	165.33	0.43	771.31
Year	Simulation	Qsurf	Qlat	Qgw	Perc	SW	ET	Wat.YLD	Sed.YLD	Prec.
2008	SIM1	109.58	7.95	12	35.62	180.59	542.41	132.07	22.25	644.3
	SIM2	100.3	7.08		22.8	161.39	565.53	109.41	21.82	644.3
	SIM3	1.42	16.77					42.07	4.38	644.3
	SIM4	27.91	2.59	52.26	79.18	168.09	570.44	65.48	0.23	644.3
Year	Simulation	Qsurf	Qlat	Qgw	Perc	SW	ET	Wat.YLD	Sed.YLD	Prec.
2009	SIM1	291.75	10.15	35.29	72.13	182.37	596.04	339.89	67.71	937.3
	SIM2	279.07	8.89		49.96	166.93	628.28	289.78	68.12	937.3
	SIM3		1.78	32.93				103.57	13.79	937.3
	SIM4	97.45	4.09	128.61	199.68	173.37	648.65	160.33	0.96	937.3
Year	Simulation	Qsurf	Qlat	Qgw	Perc	SW	ET	Wat.YLD	Sed.YLD	Prec.
2010	SIM1	179.04	12.35	42.87	93.64	183.64	592.12	237.58	44.92	837.8
	SIM2	168.78	11.21		76.56	171.27	619.62	182.41	43.91	837.8
	SIM3		2.24	44.06				88.13	8.84	837.8
	SIM4	66.44	4.06	99.05	165.23	173	629	124.34	0.58	837.8

The provision of one farm pond in each sub basin of the watershed, proved to give good results. All other BMPs proposed in fourth simulation, though easy in construction, cheaper in cost and fast in implementation are not feasible. They are proved to be the best solutions for water and soil conservation, but in practice, convincing the farmers for having all these structures in their fields becomes a difficult task. On the contrary, for each sub basin at least one farmer becomes ready to construct the farm pond as it is easy and fast in construction .Figures below show the graphs representing the corresponding changes in corresponding scenarios.

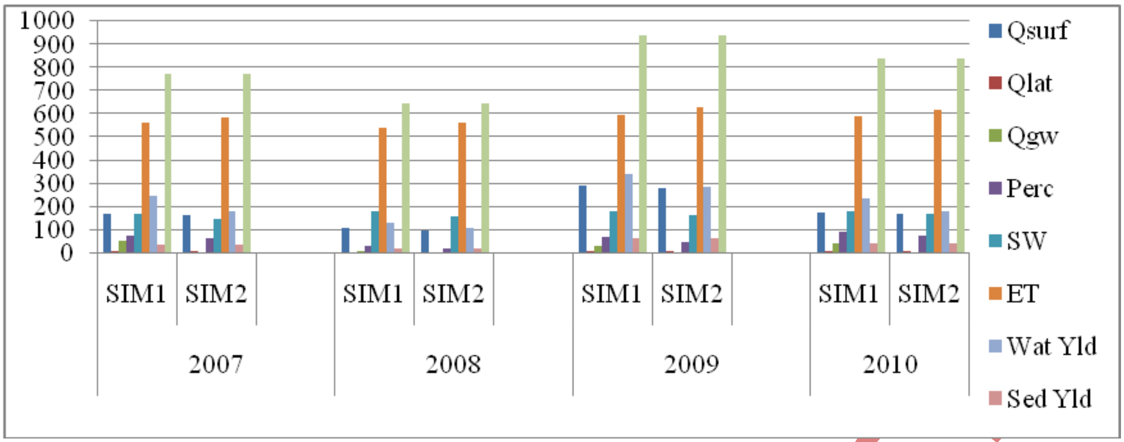

Fig.7 Graph presenting the impact of parameter changes on watershed (SIM 2)

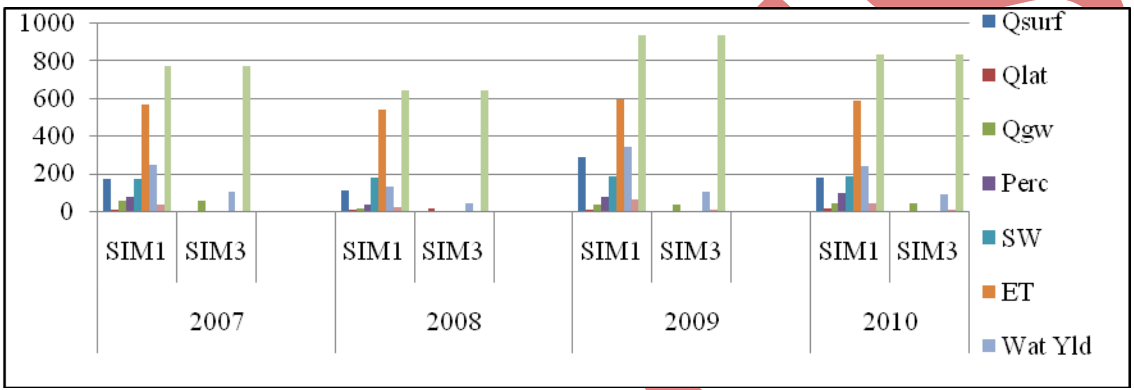

Fig.8 Graph presenting the impact of Farm Ponds on watershed (SIM 3)

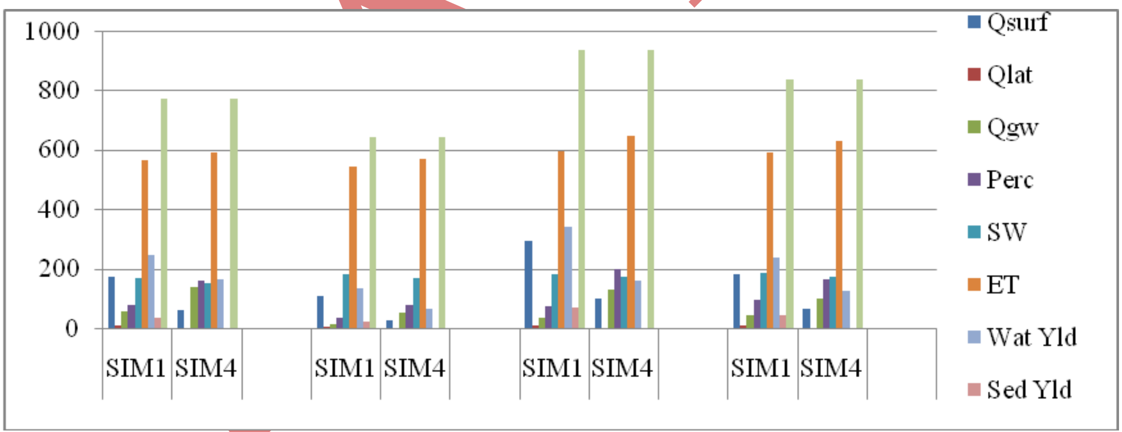

Fig.9 Graph presenting the impact of BMPs on watershed (SIM 4)

Being an ideal watershed, Kaneri will be self sustained in its domestic and even agricultural water needs , if the appropriate watershed management practices especially farm ponds will be implemented in it. If the farmers of Kaneri will construct the farm ponds in their fields, it will certainly solve the problem of water scarcity of the village.

SWAT model run gave satisfactory results for the simulations in different scenarios. Results obtained in the SWAT model simulation were satisfactory, revealing the importance and best suitability of farm ponds in watershed management of rural areas.

VII. CONCLUSION

Thus, it is concluded that, a physically-based SWAT model can be used not only to identify the critical areas but also to explore the capabilities of the model to identify the best management practices. If discussed with the community leaders about implementation of the structures, making them aware about the efficient working of the scenarios, they will certainly participate in the process of watershed management to make their communities self sustained in water needs.

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