MGNREGA BASED MICROLEVEL WATERSHED PLANNING AND ANALYSIS USING SWAT MODEL

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ABSTRACT

Management of natural resources is considered as key approach for achieving sustainable rural development in the country. Under the act of Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) issued by government of India, it is intended to use ridge to valley principle for treating rural areas to attain soil and water conservation and to achieve best possible employment generation. To attain this rural development, geospatial methods are utilised which provide wide scope for planning, implementing and monitoring Natural resources management activities. Current study aims at understanding the impact of implementing NRM activities in a drier micro watershed cluster through geospatial datasets and local level hydrological process model. SWAT (Soil and Water Assessment Tool) model is adopted for modelling of this micro watershed on seasonal approach using high resolution image-based inputs. The study area considered is IWMP/36-2011-12 of Prakasam district in Andhra Pradesh, India. Study relies on characterisation of Hydrological Response Units (HRUs) by using Crop seasonal Land Use and Land Cover maps, Digital Elevation Model, Soil maps and Climate data. From the results, it is clear that SWAT helps in obtaining clear understanding of the Runoffs and Sediments of the micro watershed on a season-based approach. This study mainly addresses the regional level study with temporal variations followed by treatment of a cluster of micro watershed done under IWMP (Integrated Watershed Management Program) of Department of Land Resources (DoLR).

Keywords – *GIS, Hydrological outputs, IWMP, Micro watershed, QSWAT.*

1. Introduction

The fresh and clean water is a limited source. Due to the occurrence of natural droughts and improper usage of water, this limited source is degrading day by day. Protecting the natural resources from further damage is critical. In order to avoid a situation of water scarcity, the conservation of water has to be considered. So, it is essential step to conserve water by certain conservation activities. The rain water, which is considered as source of fresh water can be trapped by the help of mini percolation tanks. The overflow runoff of rain water can be altered by check dams, rock gabions and other structures. The productivity of agriculture can be maintained by digging farm ponds to provide adequate water to the fields even at dry times. Planting of trees will stop the runoff water and prevents top fertile layer of soil getting eroded. With simple conservation techniques, water can be trapped and saved for the future generations.

The Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) notified on September 7, 2005, majorly concentrates on enhancement of livelihood security needs of households in rural areas of the country by providing at least one hundred days of guaranteed wage employment in a financial year to every household whose adult members volunteer to do unskilled manual work.

The identification of suitable sites for the construction of conservation activities can be better achieved by considering a Micro watershed scale. The modelling of the watershed helps to understand the impacts of the NRM (Natural Resource Management) activities that are taken place on the Hydrology of the watershed. This planning and modelling of the watersheds can be obtained by many GIS interfaces. The Remote sensing and GIS is a multidisciplinary rational approach in optimum utilization of natural resources. This facilitates the integrated watershed management, in the watershed to enable sustainable development. Site suitability evaluation in the watershed is a major step of watershed management. The current study concentrates on conserving water for watershed use, sediment reduction, flood protection in valley regions and improved productivity over three crop seasons. A Process model is set to analyse the variations in hydrological outputs after conservation activities. SWAT (Soil and Water Assessment Tool) is such interface which is considered as a best modelling tool to study the changes in hydrological cycles. This considers the land use practises and soil cover as major components. In India GIS based SWAT modelling tool has been widely utilized and recognized as one of the best tools for watershed management (Tripathi et al,2013). It is clear that to attain sustainable land and water management, the watershed is considered as the basic management unit (Chowdary et al,2009). This modelling utilises the geospatial datasets of the study area to generate outputs.

The nature of watershed management can be assessed by the quantity and quality of water produced by the watershed. To understand the water management problems, it is essential to analyse and quantify the trends of hydrological processes that are taken place in the study area (Vidula et.al.,2015). After a proper understanding of spatial and temporal variations of these hydrological processes a water conservation plan can be made accurately.

The objectives of the study are to identify the sites for the construction of four category works of NRM activities. The impacts of these water conservation structures on hydrology of watershed is evaluated. This study is made by considering the seasonal variations of landcover over a period of three years 2013-15.

2. Study Area

The study area is an IWMP-36 (Integrated Watershed Management Programme) in Paleru basin of Prakasam district and represented as Praksam-IWMP-36/2011-12. The Prakasam district is in Andhra Pradesh, India and is situated between latitudes 79.32 E to 79.4 3E and 15.20 N to 15.28 N longitudes. The major crops of the area are Paddy, Cowpeas, vegetables, Red gram, Green gram and Black gram. This area is occupied by eight villages namely Nagireddypalle, Chodavaram, Umamaheswarapuram, Chirladinne, Guravajipeta, Vangapadu, Chennakesavapuram, Jammalamadaka with population of around 10,400. The total geographical area is nearly 56 sq. kms. The maximum and minimum elevation of the area are 227 m and 12 m. Initially, an area is selected to implement planning based on the ridge to valley principle. In this study, the area of interest is so considered because, a nearby area named Chilamkur has gone through the several ridge to valley treatments. Increase in water cover due to conservation activities are clearly seen in the landscape, which is adopted as model inputs in the study site. This is shown in figure 2.1.

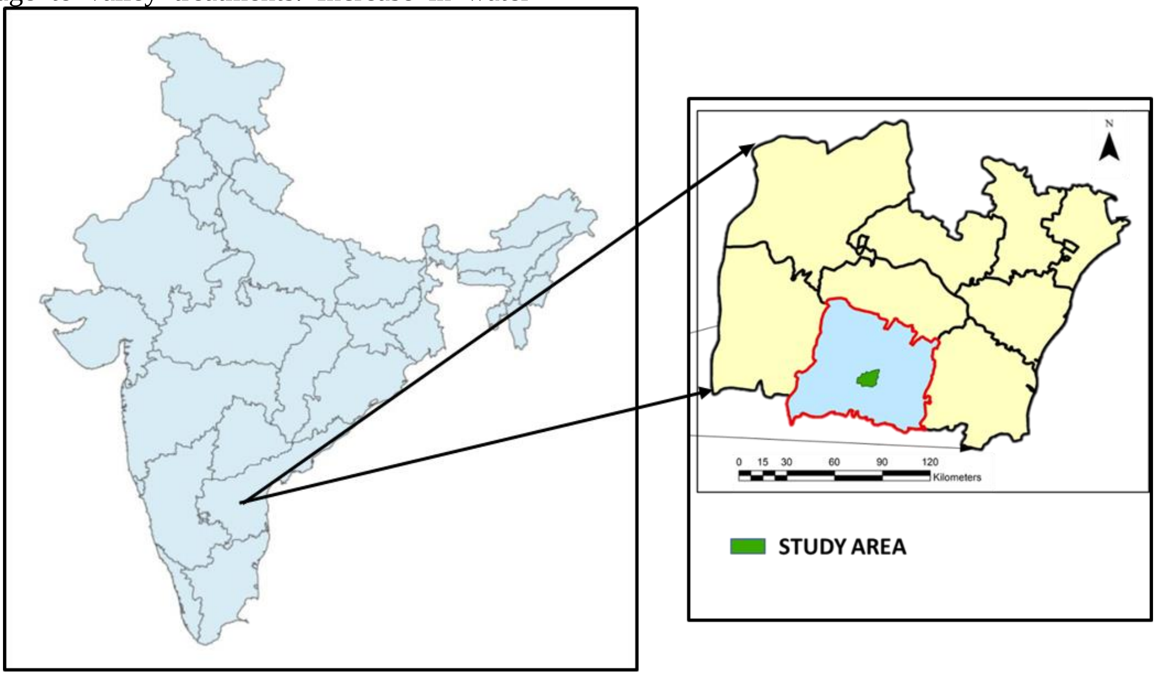


Fig 2.1 Study Area

3. Materials and Methods

3.1 Methodology

The methodology adopted for the current study involves two stages Planning and Analysis of structures. The Planning of the conservation structures is obtained from a manual MGNREGA issued by "Ministry of Rural Development" (MoRD). The methodology of this planning is shown in the flowchart of figure . After proper planning, the analysis of the structures is made using a Hydrological model SWAT (Soil and Water Assessment Tool).

3.2 Digital Elevation Model (DEM) The current area is plain terrain with maximum elevation of 227 metres and minimum elevation of 12 metres. It is characterized by streams and lakes with a plain terrain.

3.3 Soil Map The LISS-IV image of study area is taken and segmented with a compactness factor, fineness factor. The segments are classified based on the ground conditions, land cover and other factors. The attributes are assigned in the classification table to the classified values. This image with classified attributes is exported as vector layer with geocoded co-ordinates. There are six types of soils Clayey Loam, Gravely Sandy Loam, Gravely Silty Clayey Loam, Sandy Clayey Loam, Sandy Loam, Silty Clayey Loam.

3.4 Slope Map Slope can be explained as the measure of steepness. Here, the slope is calculated as Percent Rise to meet the guidelines of Samarthya manual.

3.5 Flow Direction Raster The direction of flow from every cell in the raster is calculated using the Flow Direction function and the corresponding raster is Flow Direction Raster. This function considers input layer as surface and produces an output as raster showing the direction of flow out of each cell. The Resampling of the Flow Direction Raster is done and symbology is changed to arrows to represent the flow direction with arrows tending to that direction.

3.6 Stream Order The smallest tributaries are given with a smallest number 1 and the order number is increased with branches of tributaries.

3.7 Farm Sites The total farm parcels of the entire study area is digitized manually to obtain a map of farm sites. This is major input for planning of farm ponds.

3.8 Village Proximity Zones The village proximity zones are prepared by creating a buffer of 250 metres to the villages in of study area. The proximity to the village for the current study is considered as 250 metres.

3.9 Land Use and Land Cover This is one of the important inputs for the current study. As, the study concentrates on a watershed at micro level, a finer resolution Land cover is to be adopted. This also varies the hydrological outputs as the model performance is majorly dependent on the Land cover map. To answer this, Landsat images of the study area are collected for respective crop seasons for the years 2013-15 and E-cognition software is used to obtain the seasonal landcover maps. The seasonal land cover maps are shown in the figure 4.6.

3.10 Climate Data The study area is merely dry area which receives rainfall during months of September, October and November. The average annual rainfall received is nearly 740 mm every year. The mean maximum temperature recorded is 330 C and mean minimum temperature recorded is 240 C. The daily values of precipitation and minimum, maximum temperature are taken for the period of 2013-15.

3.11 Water Budgeting of Study area The Water Budgeting is a water management tool that helps to estimate the amount of water that a landscape requires. The average annual rainfall of the area is nearly 736 mm. This can be converted into hectare metres by multiplying it with the area in hectares. In this, 9 % corresponds to Ground water, 40 % to Runoff, 10 % Soil Moisture and 41 % to Evapo-transpiration. The total volume of water bodies in the study area is nearly around 320 Ha m. The total water availability of the study area is nearly around 1114 Ha m.

The total population is nearly 10400 distributed among the eight villages. The crops grown in the area are paddy, red gram, green gram, cowpeas and some vegetables. The water requirements for population as per standards are 3 Ha m per 1000. The water requirements for crops and for poultry are considered from Samarthya manual. The total water requirements are summarised as 1160 Ha m. The total Deficit observed is nearly 46 Ha m.

4. Results and Findings

The identification of suitable sites for construction of Farm ponds, Check dams, Percolation tanks and Plantations are made by considering necessary Thematic layers. The essential inputs for planning and analysis are prepared and utilised for proper identification of sites for the construction of conservation structures. The impact of these structures on the hydrology of the watershed plays a key role in the current discussion.

4.1 Farm Ponds The Flow direction map and slope map are essential input layers for selecting ideal locations for Farm ponds. From the planning rules, Slope criteria and flow direction farm ponds are taken into consideration and suitable sites are identified. A total of 364 Farm ponds of dimension 12.8*6.4 metres with a volume of 500 cubic metres are planned and distributes over entire area for a period of three years.

4.2 Percolation Tanks The percolation tanks are majorly planned on second and first order streams of drainage network. The percolation tanks planned per year are shown in three maps in figure. The percolation tanks are of dimension 25*25 metres with a volume of 1500 cubic metres.

4.3 Check Dams The check dams are majorly constructed on third and fourth order streams of drainage network. Each check dam of dimension 35*35 metres with a volume capacity of 3000 cubic metres is planned. The slope should be less than 5%, is taken into consideration before planning of check dams on drainage networks.

4.4 Plantations The village proximity zones are prepared from the existing land cover. The waste lands in these zones are converted to plantation sites. For the proper identification of plantation sites proximity for villagers is considered as criteria. A total of 172 Ha is planned to be converted from waste lands to plantations.

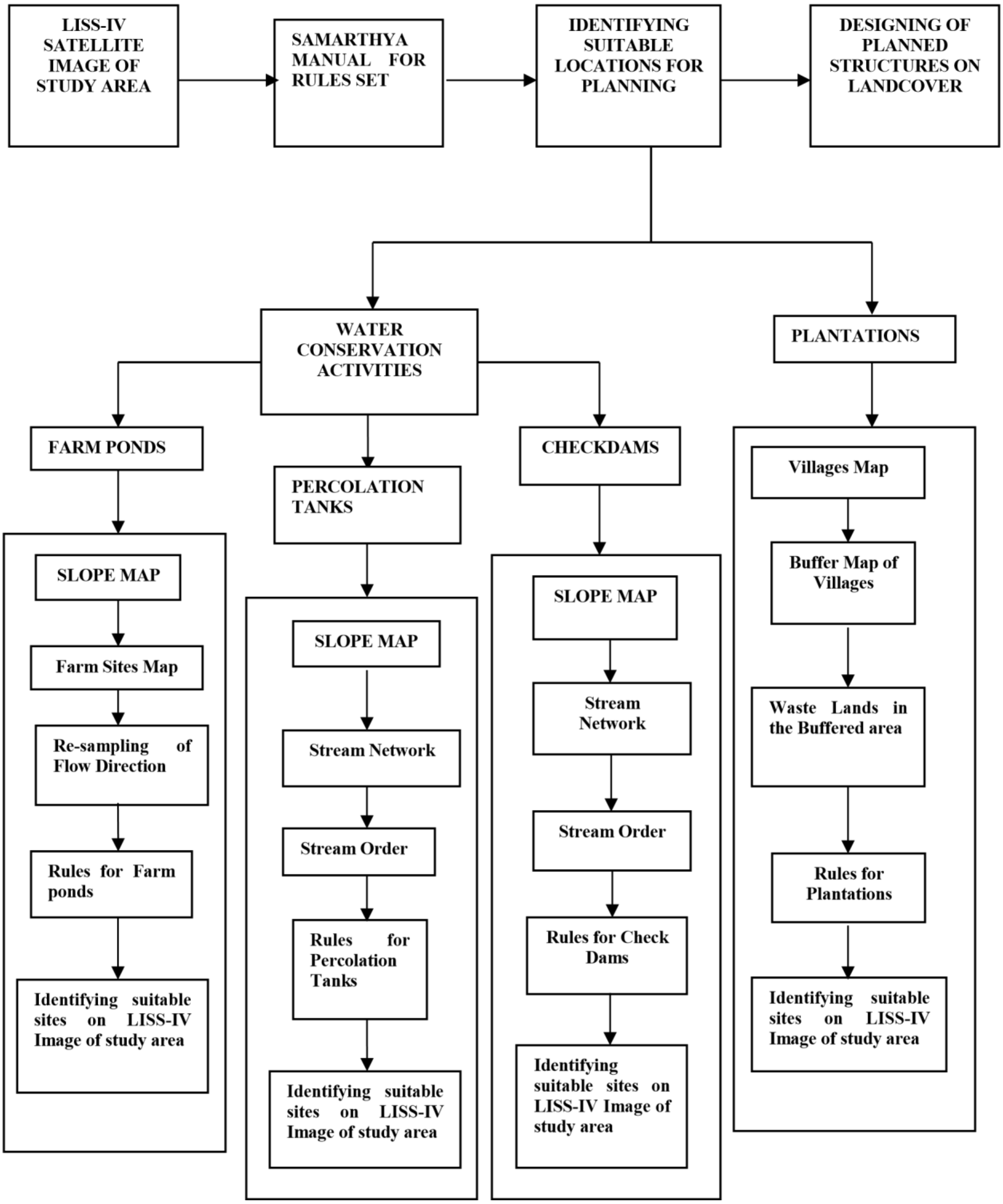
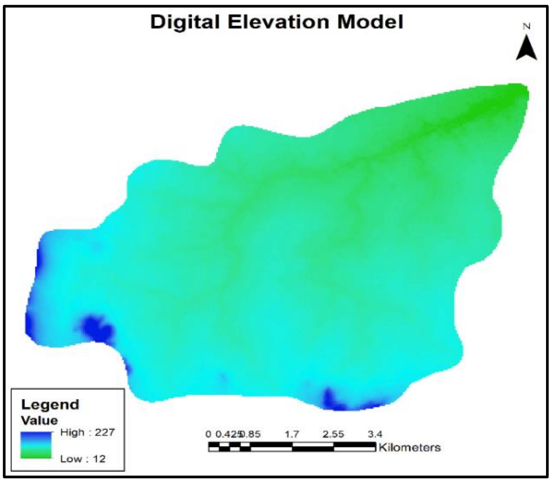


Fig 4.1 Flowchart Methodology of planning of water conservation structures

4.5 SWAT Model Run

A total of 25 sub basins are created in the entire study area for every seasonal run. It is observed that there is no change in number of sub basins but there is change in the number of HRU's formed. This may be observed due to variations in crop land and Current fallow land in landcover and also interventions planned. These sub basins are shown in the fig 4.10. The farm ponds, Percolation tanks and check dams planned comes under water bodies class as they retain water in them as a reservoir /lakes/river. The total HRU's created for SWAT Model with and without NREGA structures is in the table 4.1.

The land cover distribution of every crop season is compared in the table 4.2. This highlights the variation of crop cover in every



season which considered as a key concept to the current study. A typical graph 4.12 is shown to elucidate the variation of the crop and fallow lands with varied crop seasons.

Fig 4.2 Digital Elevation Model of Study area

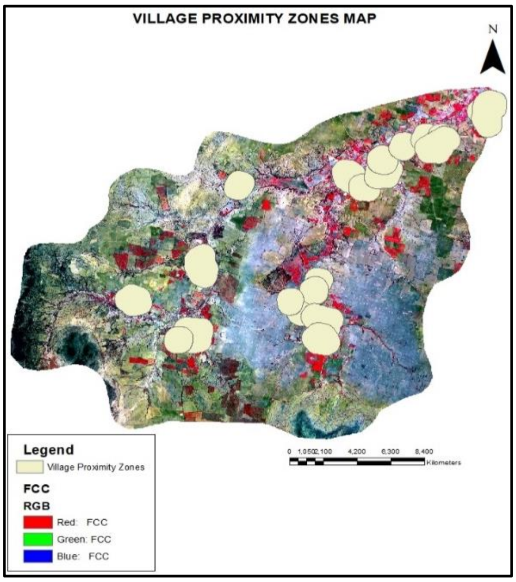
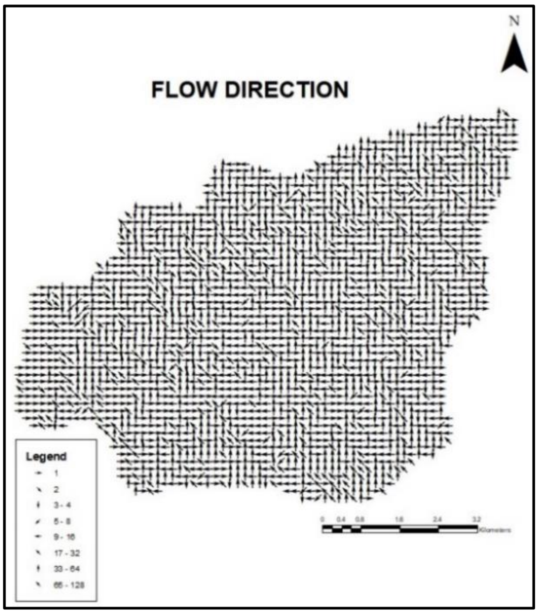


Fig 4.3 Village Proximity Zones

4.6 Hydrological Outputs

4.6.1 Seasonal Rainfall The daily precipitation values of every crop season are summed up to understand the seasonal variations of rainfall in

the years 2013-15. It is observed in fig 4.9, that the Kharif season is having more rainfall compared to other seasons. An optimum amount of rainfall is occurring during Rabi



reason which can also be a reason for more cropping area in Rabi season. The average

Fig 4.4 Flow Direction Raster of Study area

rainfall occurred during 2013-14 is 584.34 mm, in 2014-15 is 373.6 mm and for the year it is nearly 812.7 mm.

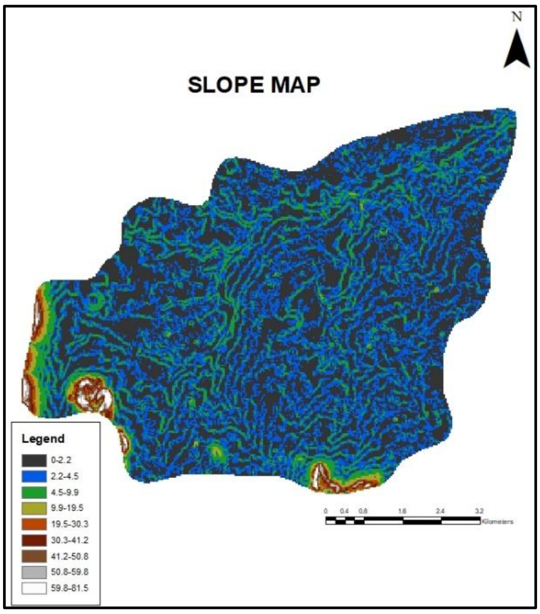


Fig 4.5 Slope map of study area

4.6.2 Seasonal Runoff

The seasonal runoff is obtained by SWAT model setup for every season with season sensitive input parameters. It is clear that the presence of conservation structures and

plantations have reduced the runoff. The seasonal variations in the runoff is calculated to analyse the effect of conservation structures.

SEASONAL LAND COVERS 2013-15

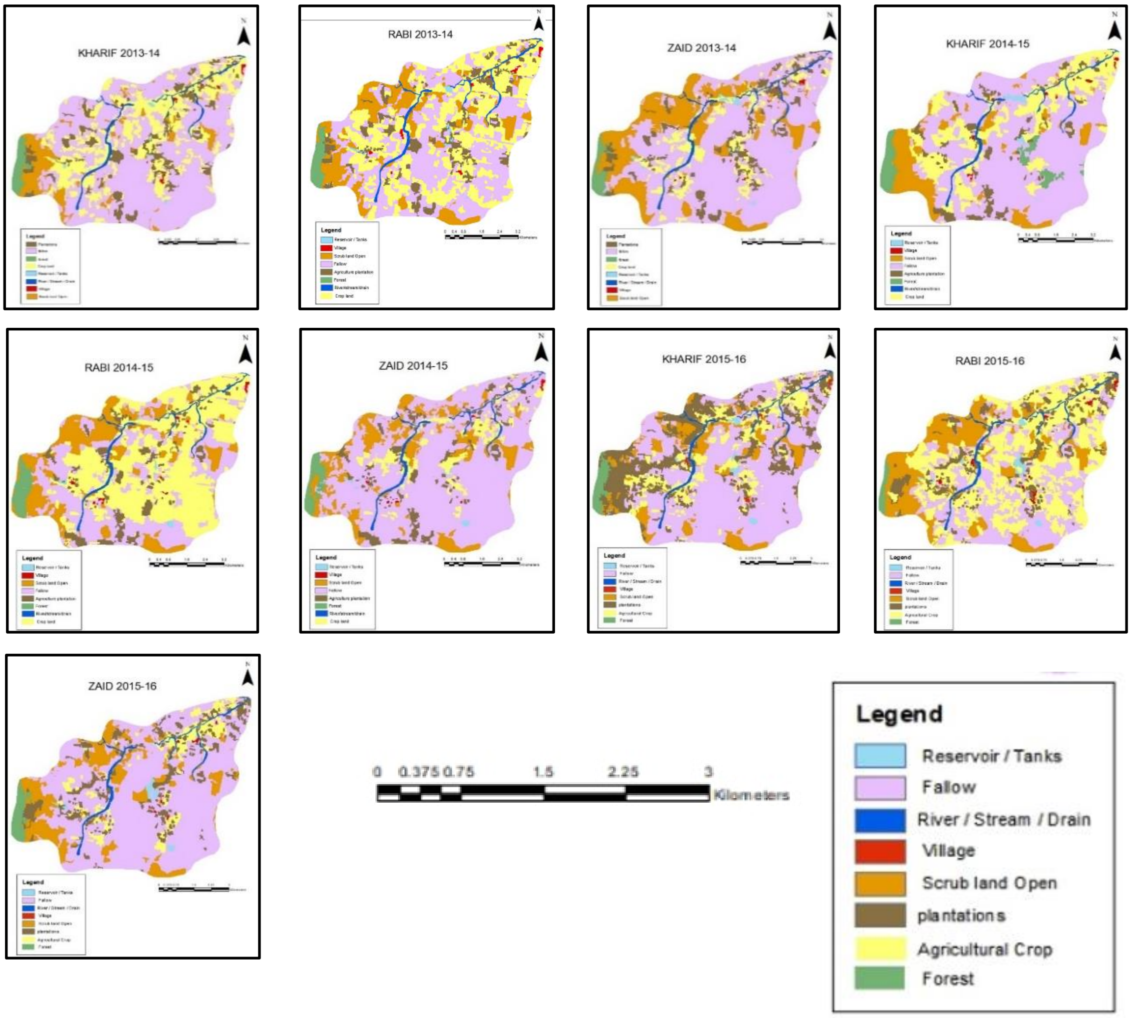


Fig 4.6 Seasonal Landcover maps of study area over the period 2013-15

Table 4.1 HRU’s created after SWAT Model run for with and without interventions

Year	Season	HRU’s Created (Without Interventions)	HRU’s Created (With Interventions)
2013-14	Kharif	265	251
	Rabi	241	310
	Zaid	225	225
2014-15	Kharif	305	313
	Rabi	276	305
	Zaid	250	297
2015-16	Kharif	276	294
	Rabi	289	309
	Zaid	295	317

Table 4.2 Distribution of water conservation structures for every season over a period of three years 2013-15

Year	Season	Farm ponds	Check dams	Percolation Tanks	Plantations (Area in ha)
2013-14	Kharif	30	3	4	12
	Rabi	45	4	6	20
	Zaid	25	2	6	12
2014-15	Kharif	36	3	6	18
	Rabi	62	4	9	31
	Zaid	25	3	8	18
2015-16	Kharif	31	3	6	18
	Rabi	79	4	9	28
	Zaid	31	2	7	15

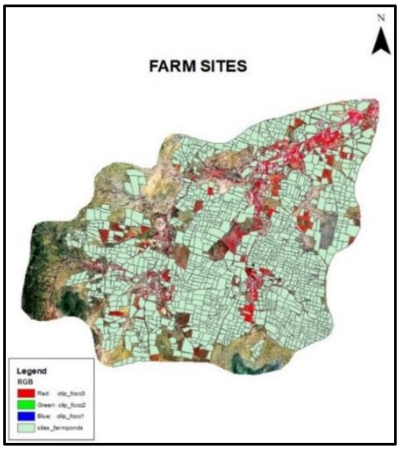


Fig 4.7 Farm Parcels of study area

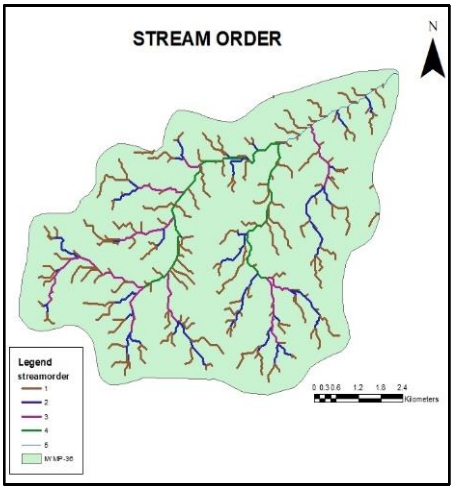


Fig 4.8 Stream Order of study area

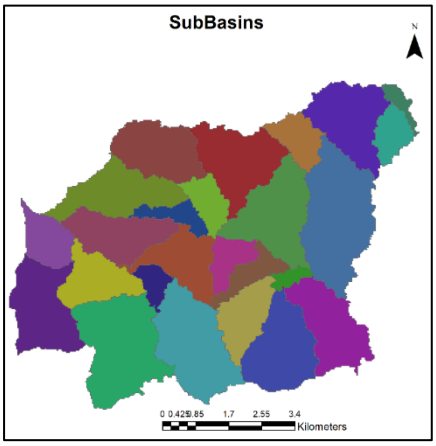


Fig 4.9 Subbasins Map of SWAT Model Run

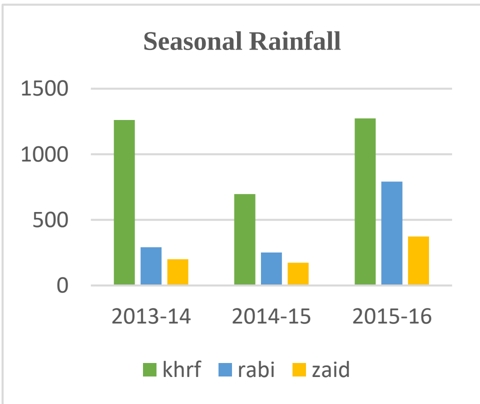


Fig 4.10 Graph of Variations of Seasonal Rainfall of study area

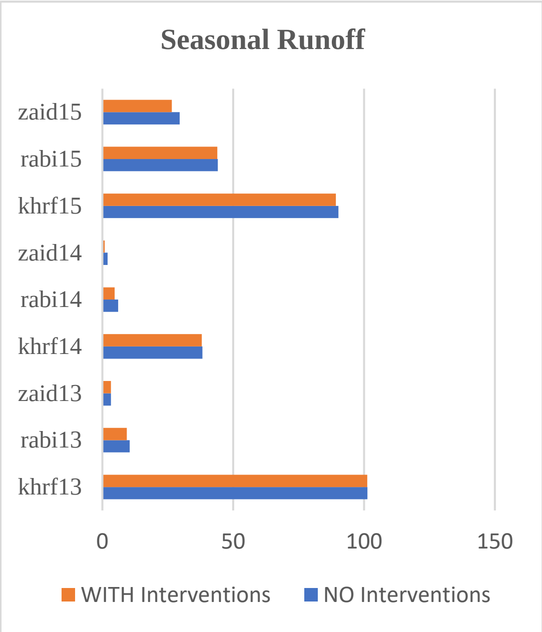


Fig 4.11 Graph of Seasonal Runoff variations with presence of interventions

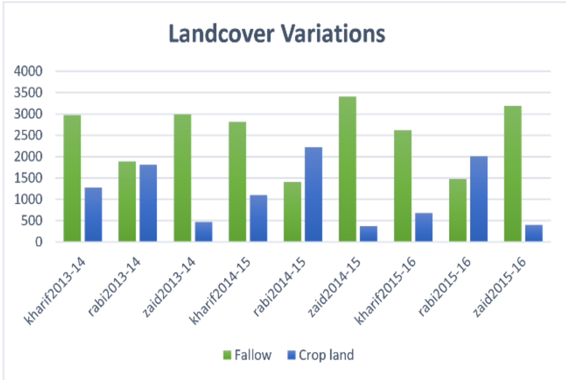


Fig 4.12 Graph of Seasonal Landcover variations of Fallow land and Crop land

4.6.3 Yearly Runoff A graph 4.13, is made to get a clear approach of runoff values estimated. A variation of 1.14 mm is observed in the year 2013-14, 2.682 mm is observed during second year 2014-15 and a major runoff of is observed 4.11 mm during third year of planning 2015-16.It is clearly indicative that as the number of conservation activities increased, reduction of runoff is also increased.

4.6.4 Sediments

The estimated sediments content also follows the same pattern of runoff as these both are directly linked to each other. A table is made to display the seasonal runoff and sediments variations with interventions. This is also dependent on the major soil types present in the study area. A graph 4.14, is plotted to show the difference in the sediment values estimated. It is observed the water conservation structures planned are useful to trap water where as a major top soil loss can also be avoided using these structures. Since runoff is reduced an equal amount of sediments loss is reduced which in turn prevents top soil loss. The reduction is observed to be more in the third year of planning, 2015-16.

Table 4.3 Distribution of Land cover types over three crop seasons from 2013-15

Land Cover	**2013-14 Kharif (ha)**	**2013-14 Rabi (ha)**	**2013-14 Zaid (ha)**	**2014-15 Kharif (ha)**	**2014-15 Rabi (ha)**	**2014-15 Zaid (ha)**	**2015-16 Kharif (ha)**	**2015-16 Zaid (ha)**	**2015-16 Zaid (ha)**
AGRR	437.99	443.49	392.22	251.18	290.85	250.11	367.61	370.02	367.33
AGRL	1272.59	1808.39	466.50	1127.60	2296.84	377.56	720.93	2102.30	457.43
RNGB	402.12	736.09	1044.19	580.79	883.75	770.91	1158.81	963.20	771.82
FRSE	108.51	104.34	90.69	218.20	136.63	117.02	99.29	51.97	119.59
WATR	114.96	133.64	137.40	144.39	132.70	128.86	142.54	157.05	150.52
BSVG	2820.03	1884.23	2989.61	2831.70	1410.80	3513.36	2654.67	1498.80	3296.31
URLD	11.37	16.02	5.59	13.75	15.14	7.61	14.00	22.09	11.05

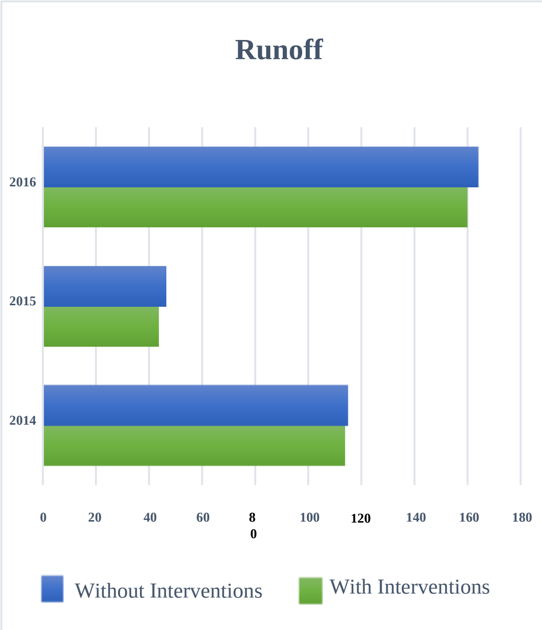


Fig 4.13 Graph variations of Yearly Runoff values with and without interventions

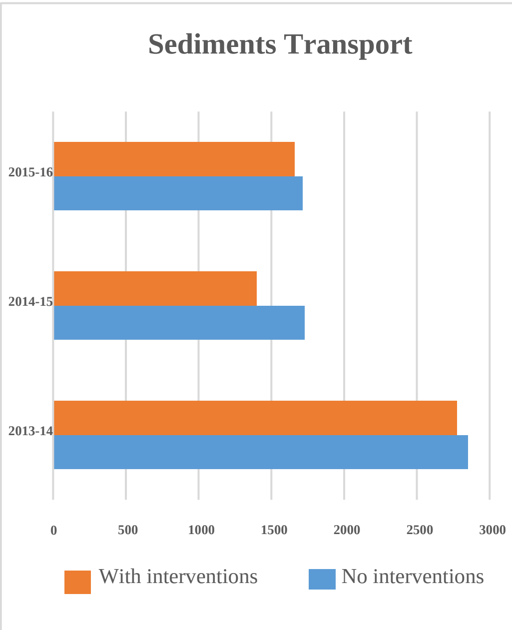


Fig 4.14 Graph Variations of yearly sediments transport with and without interventions

5. Discussions and Conclusions

Current study aimed at understanding the role of a simulation model in analysing the impact of ridge to valley treatments planned under Mission Water Conservation of Department of Rural Development, Government of India across entire country. Geo-MGNREGA is a distinguished space technology application project, initiated under PMO directives and implemented on Bhuvan portal and current approach will be the sequel in planning future NREGA activities across India. The study essentially focuses on providing spatially explicit advisory on implementing NRM (Natural Resource Management) interventions specified under NREGA as set of about 100 activities in public and private land parcels. The scale at which SWAT is applied for database of land cover at 1:10000 and can be one among prime attempts in this direction. As of now, similar watershed conservation treatments are monitored for IWMP (now WDC-PMKSY) watershed projects, centrally funded by Department of Land Resources using satellite image-based cover changes. The total activities recognized to be implemented under NREGA are 141. Out of them only 100 activities come under Natural Resource Management (NRM) activities.

The present study concentrated on planning selected activities such as farm ponds, check dams, percolation tanks and plantations. Seasonality component generally gets normalized for a general process model, where as in current study, simulation addresses each season in all the three years considered as separate land cover context as to make analysis spatially and temporally explicit. It is necessary that once proper planning has been done, an understanding should be made to about the impact of these structures by modelling as well as monitoring through appropriate time intervals. Presently several physically based simulation models are in use for simulating the runoff and sediment yield of small and large watersheds. Among these models Soil and Water Assessment Tool (SWAT) is the latest tool incorporating several process inclusions, which is used successfully for simulating runoff and sediment yield from small as well as large watersheds. Model has potential to address several soils, water as well nutrient loading processes apart from simulating urban watersheds. The current study is based on planning and analysis of planned activities. After planning, SWAT Model is set to run with these activities giving suitable codes. Model simulation runs incorporate Land cover contexts for the nine seasons with and without comprising planned activities. This highlights the comparison of variations in outputs with planned activities and without these activities. As the scale of these activities are very small compared to the Landcover, the impact is very small at this scale. But, the impact is clearly observed with very small decimals variations. The runoff is decreased with the increase in planned interventions. It can be concluded that the SWAT Model gives accurate results for a study where scenario creations are made.

From the above study, we can conclude that the impact of conservation structures is observed clearly on hydrological parameters. With the amount of rainfall occurred, these parameters are directly related. It is indicative that the rainfall decreased by 36% from 2013-14 to the year 2014-15 and increased by 39% to the year 2015-16. The presence of interventions reduced the runoff by 1 % during the year 2013-14, 5.7% in the year 2014-15 where as 2.7 % during 2015-16. This study also helped to understand the hydrological process under the influence of conservation structures. The SWAT model is identified as an appropriate tool to evaluate hydrological parameters at a finer scale with temporal variations. As the study is concentrating on seasonal variations, the runoff is considered for every season as it is a primary indication of impact of interventions. The effect of interventions has shown a considerable change in sediments transport which is proven using model approach. A nearly similar trend is also observed in other parameters. This study also helped to understand the hydrological process under the influence of conservation structures. The SWAT model is identified as an appropriate tool to evaluate hydrological parameters at a finer scale with temporal variations. As the study is concentrating on seasonal variations, the runoff is considered for every season as it is a primary indication of impact of interventions. It is observed that the decrease of runoff in kharif season is more during 2014-15 by 4.6% and less during 2013-14 by 0.07%. Similarly, during Rabi season, the seasonal runoff reduction is more in 2014-15 by 9.67% whereas less during 2015-16 by 0.93%. The amount of Zaid season runoff is reduced more during 2014-15 by 4.53% and less during 2013-14 by 0.7%. This is mainly due to more crop cover during the year 2014-15 and variations in Rainfall.

References

- Ammar, Adham, Coen R, (2016). Identification of suitable sites for rainwater harvesting structures in arid and semi-arid regions. *Science Direct*, volume 4, page108-12072
- Bhatt V K, Tiwari A K and Sena D R, (2016). Application of SWAT model for simulation of runoff in micro watersheds of lower Himalayan region of India. *Indian Journal of Soil Conservation*, Vol. 44, No. 2, pp 133-140, 2016
- Burges S G, (1986). Trends and Directions in Hydrology. *water resources research*, Vol. 22, No. 9, August 1986
- Chowdary V M, Ramakrishnan D, Srivastava Y K, Chandran V, Jeyaram A (2009). Integrated Water Resource Development Plan for Sustainable Management of Mayurakshi Watershed, India using Remote Sensing and GIS. *Water Resources Management* 23:1581–1602
- Dhruvesh P P, Naresh N, (2016). Runoff potential estimation of Anjana Khadi Watershed using SWAT model in the part of lower Tapi Basin, West India. *Sustain. Water Resour. Manag.*, 2:103–118
- Gosain A K, Rao S and Basuray D, (2006). Climate change impact assessment on hydrology of Indian river basins. *CURRENT SCIENCE*, VOL. 90, NO. 3
- Mohammad M E, Ansari N A and Knutsson S, (2012). Application of SWAT Model to Estimate the Runoff and Sediment Load from the Right Bank Valleys of Mosul Dam Reservoir. *ICSE6*, Paris.
- RANGO A, (2009). Application of remote sensing methods to hydrology and water resources. *Hydrological Sciences Journal*, 39:4, 309-320
- SAMARTHYA, Technical Training Manual, (2015). A Module on MNNREGA

- Sánchez M, Lopez A, Acuna V, and Ziv G, (2015). Sensitivity analysis of a sediment dynamics model applied in a Mediterranean river basin: Global change and management implications. *Science of the Total Environment,* 502, 602–610.

- Schilling K E, Jha M K, Zhang Y K, Gassman P W, Laura, Normana M and Niraula R, (2016). Model Analysis of check dam impacts on long-term sediment and water budgets in Southeast Arizona, USA, *Journal of Ecohydrology and Hybridology*-94

- Shirisha P, Venkata Reddy K, Deva Pratap, (2015). Experimental watershed for real time flow simulation, *IJRET: International Journal of Research in Engineering and Technology*, Volume 04, Special Issue 11: 2319-1163.
- Tripathi C N and Gosain A K (2013), "Micro Watershed Modeling in India Using GIS Technologies and Agricultural Policy Environmental Extender (APEX) Model. A Case Study", *International Journal of Engineering Research and Application*, Vol. 3, Issue 2 pp:1640-1648.

- Tripathi M P, Panda R K, Prardhan S, Sudhakar S, (2002). Runoff Modelling of a Small Watershed Using Satellite Data and GIS, *Journal of the Indian Society of Remote Sensing*, Vol. 30, No. 1&2, 2002.

- Vidula A S, Sushama S K, (2016). Simulation of Runoff and Sediment Yield for a Kaneri Watershed Using SWAT Model, *Journal of Geoscience and Environment Protection,* 4, 1-15
- Vinayak N M, Umesh J, (2013). Watershed Planning and Development Plan by Using Rs and GIS of Khultabad Taluka of Aurangabad District, *International Journal of Information and Computation Technology, ISSN,* 0974-2239 Volume 3, Number 10 (2013), pp. 1093-1100.

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