Rainfall Runoff Modelling By Using RS And GIS (A Case Study Of Bhima River Basin At Gulbarga District)

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Abstract: **At present water is the main source for mainly industrial purpose, Agricultural and power generation. To estimate this rainfall-runoff model at an selected drainage basin there are different models and methods has been implemented. Rainfall runoff is an important component contributing significantly to the hydrological cycle, design of hydrological structures and morphology of the drainage system.Is always efficient but is not possible for most of the location at desired time. Use of remote sensing and GIS technology can be used to overcome the problem of conventional method rainfall runoff estimation that considers parameter like slope, vegetation cover, area of watershed.**

Under basin and sub-basin using Arc-SWAT, the world about Arc-GIS. Different maps The guide made from an perspectives of the basin gives a point of Perspective of the water shed and would using for hydrological Bhima stream basin in Gulbarga, Karnataka. Hence it is estimated that rainfall-runoff for Bhima river basin. It can be proposed to construct hydrological structures.

Keywords: **Rainfall, Runoff , RS, GIS**

I. INTRODUCTION

Land and water are the two most vital natural resources of the world and these resources must be conserved and maintained carefully for environmental protection and ecological balance. Prime soil resources of the world are finite, on-renewable over the human time frame, and prone to degradation through misuse and mismanagement.

The world population has increased rapidly over the last 150 years and continues to do so, which affects hydrologic resources on both a local and a global scale. An assessment of the impact of land use changes on water resources is one of the recent thrusts in hydrological modelling . It is expected that approximately 60% of the world's population will be living in urban areas by 2030. There are 8000 km^2 of land converted to urban growth every year. In India, out of a total geographical area of 329 M ha, an estimated 176 M ha of land, constituting an area of 53% suffers from deleterious effect of soil erosion and other forms of land degradation and with the increasing population pressure, exploitation of natural resources, faulty land and water management practices, the problem of land degradation will further aggravate.

Runoff modeling is a very important topic of research that can be utilized for management and control of water resources. In most of arid regions in particular, where there is shortage of hydroclimatological data and long-term records are almost absent this topic is even more important and it should be highly emphasized as a useful tool for flood assessment and control. In addition, future predictions with different scenarios in terms of changes in climate as well as environment can be undertaken by rainfall-runoff modeling.

Nowadays modeling has become a common practice in every field of endeavor, and runoff modeling is no exception. The main reason behind the using of modeling in general is the limitations of the techniques used in measuring and observing the various components of hydrological systems. Also using hydrologic models will increase our understanding and explanation of the natural phenomena and its dynamic interactions with the surrounding systems. However, under some conditions predictions can be made in deterministic or probabilistic sense. Another use of modeling is to predict how the system will respond to the future alternative conditions and actions summarized the principal purposes for which hydrological model have or can be employed.

In general they can be used for hydrologic research purposes, for forecasting and prediction of stream flow and for engineering and statistical applications (record extension, operational simulation, data fill-in, and data revision).

II. STUDY AREA

Gulbarga district officially known as Kalaburagi district is one of the 30 districts of Karnataka state in southern India. Kalaburagi city is the administrative headquarters of the district. This district is situated in northern Karnataka between 76° 04' and 77°42' east longitude, and 16° 12' and

17° 46' north latitude, covering an area of 10,951 km². This district is bounded on the west by Bijapur district and Solapur district of Maharashtra state, on the north by Bidar district and Osmanabad district of Maharashtra state, on the south by Yadgir district, and on the east by Ranga Reddy district and Medak district of Telangana state.

Fig.1. Study Area Map

The southwest monsoon sets in the middle of June and extends till the end of September. Bulk of the annual rainfall occurs during this season, which constitutes over 78% of the annual rainfall. Significant rainfall occurs during the winter monsoon owing to northeastern monsoon, which constitutes 9% of the annual rainfall. Normal Rainfall of the district is 738 mm (2005 - 2015) and actual rainfall is 674 mm (2016).

III. MATERIAL and METHODOLOGY

The Survey of India toposheets number: 56C/3,56C/4.56D/5,56C/6,56C/7,56C/8,56D/9,56C/10,56C/11,56C/12,56D/13,56C/14,56C/15,56C/16,56H/1,56G/2,56G/3,56G/4,56H/5,56G/6,56G/7,56G/8,56G/10,56G/11 in the scale of 1:50000 IRSID (PAN+LISS-III) satellite data were used for delineation of the study area and preparing the drainage network map.

This description of acquisition of various meteorological, hydrological, and remote sensing data used for data processing Procedures used for generation of different thematic layers using GIS are discussed. Methodologies for generation of input parameters for ArcView SWAT model using basic thematic layers are also described. Procedures used for calibration, validation and performance evaluation of the model.

IV. RESULT and DISCUSSION

In this chapter the performance of the model was also evaluated using statistical and graphical methods to decide the capability of the model in simulating the runoff and sediment yield from the Bhima basin and sub basin of Gulbarga region. The findings of land use/land cover changes and its impact on the hydrological regime is also presented and discussed in this chapter. As per the objectives of the project, the Bhima basin and sub basin was delineated from the SOI toposheets and various thematic maps were generated as per the requirement of the model. The database related to climate and soils were also prepared as per the input requirement of the model. Various hydrological components like surface runoff, sediment yield, ET, PET were simulated on daily, weekly and monthly basis. The predictions of the model for weekly and monthly surface runoff and sediment yield were compared with the measured counter parts. The performance of the model was also evaluated using statistical and graphical methods to decide the capabililty of the model in simulating the runoff and sediment yield from the Bhima basin and sub basin. The findings of land use/land cover changes and its impact on the hydrological regime is also presented and discussed in this chapter.

V. MODEL CALIBRATION

In the present study the AVSWAT model was calibrated for the year 2013 using the surface runoff and sediment yield data recorded at the outlet of the study area. The model was calibrated using different values of input parameters for available water content (AWC) and soil evaporation compensation factor (ESCO) within the prescribed range of the model. Though curve number is another very sensitive parameter the model was not calibrated by changing its values as standard curve numbers prescribed for Indian conditions were used for the present study. Several simulation runs were then applied until a goodness-of-fit between observed and simulated flow was obtained.

In order to compare the simulated values with the observed values coefficient of determination (R^2) and Nash and Sutcliffe (R^2 NS) efficiency methods were applied. The calibrated parameter values for AWC and ESCO were found to be 0.025 and 0.250 respectively. The time series of the simulated and observed surface runoff were compared graphically for daily, weekly and monthly basis. The calibration period reported an R2 of 0.68, 0.75 and 0.82 for daily, weekly and monthly results. The Nash-Sutcliffe R2 NS for daily, weekly and monthly results were found to be 0.53,0.52 and 0.56. Similar results have also been reported by Spruill et.al., 2012 during calibration process and were accepted for validation of the model. From the graphical analysis it was observed that the weekly comparison showed a better correlation then the daily values. The time series of the observed and simulated daily, weekly and monthly and surface runoff are shown in Fig.2 (a) and 2 (b), Fig.3 (a) and 3 (b), Fig.4 (a) and Fig.4 (b) respectively. The comparison of daily observed and simulated runoff hydrograph during calibration (2013) is shown in Fig.2 (a) and Fig. 2(b).

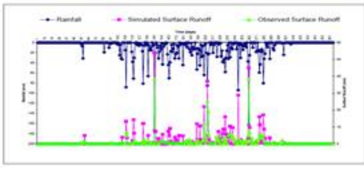

Fig.2 (a): Comparison of daily observed and simulated runoff hydrograph during calibration (2013)

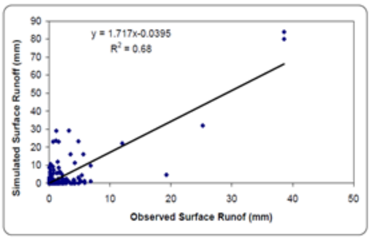

Fig.2 (b): Comparison of daily observed and simulated runoff hydrograph during calibration (2013)

The comparison of weekly observed and simulated runoff hydrograph during calibration (2013) is shown in Fig. 3 (a) and 3 (b).

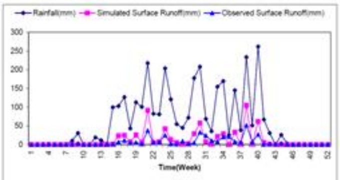

Fig. 3 (a): Comparison of weekly observed and simulated runoff hydrograph during calibration (2013)

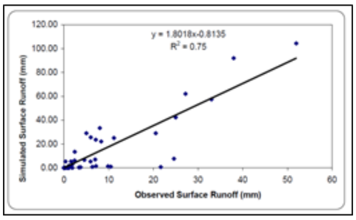

Fig. 3 (b): Comparison of weekly observed and simulated runoff hydrograph during calibration (2013)

The comparison of monthly observed and simulated runoff hydrograph during calibration (2013) is shown in Fig.4 (a) and 4 (b).

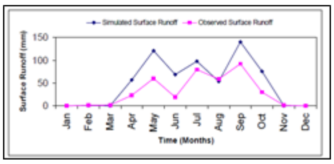

Fig.4 (a): Comparison of monthly observed and simulated runoff hydrograph during calibration (2013)

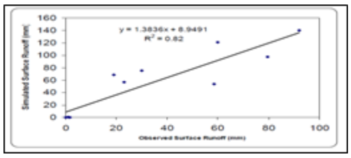

Fig.4 (b): Comparison of monthly observed and simulated runoff hydrograph during calibration (2013)

The comparison of weekly observed and simulated sediment yield during calibration (2013) is shown in Fig.5 (a) and 5 (b).

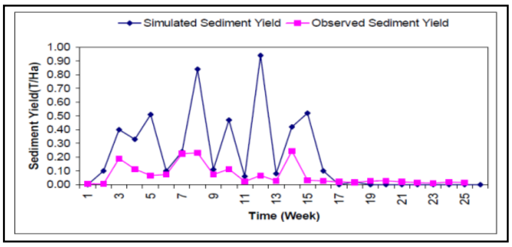

Fig.5. (a): Comparison of weekly observed and simulated sediment yield during calibration (2013)

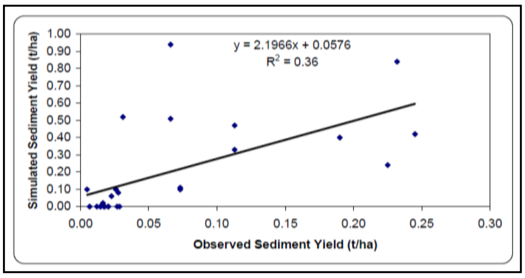

Fig.5. (b): Comparison of weekly observed and simulated sediment yield during calibration (2013)

VI. MODEL VALIDATION

After calibration the model was validated for the daily, weekly and monthly surface runoff for the year 2002 and 2013 with the corresponding measured rainfall data.

During the year 2002 the simulated runoff was 77.25mm as against the observed runoff of 224.10mm from a total rainfall of 957mm. The graphical analysis showed R^2 values of 0.43, 0.74 and 0.72 for daily, weekly and monthly runoff values for 2002 with NS values 0.57.

Table 5.6: Discrepancy in Observed Surface Runoff during the year 2002

Month	Rainfall (mm)	Simulated Surface Runoff (mm)	Observed Surface Runoff (mm)
Jan	0	0	1.04
Feb	0	0	3.54
Mar	2	0	0.94
Apr	5	0	1.69
May	254	19.76	2.53
Jun	269	30.27	52.11
Jul	114	3.82	47.3
Aug	91	2.15	45.8
Sep	70	3.02	6.69
Oct	133	18.23	48.09
Nov	0	0	8.07
Dec	19	0	6.41
Total	**957**	**77.25**	**224.21**

The model mostly under predicted the daily observed values. This can be due to limited number of rain gauge within the basin, as in the upper reach of the basin there is uncertainty about the rainfall data. The other reason could be the inaccuracy of the observed data as in few months surface runoff has been observed even in the absence of rainfall during a few months shown in Table 5.6. The comparison of daily observed and simulated surface runoff hydrograph during validation (2002) is shown in Fig.6 (a) and 6 (b).

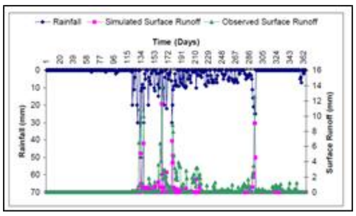

Fig.6 (a): Comparison of daily observed and simulated surface runoff hydrograph during validation (2002)

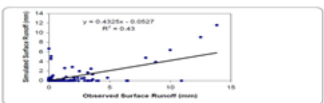

Fig. 6 (b): Comparison of daily observed and simulated surface runoff hydrograph during validation (2002)

The comparison of weekly observed and simulated surface runoff hydrograph during validation (2002) is shown in Fig.7 (a) and 7 (b).

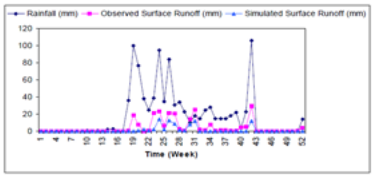

Fig. 7 (a): Comparison of weekly observed and simulated surface runoff hydrograph during validation (2002)

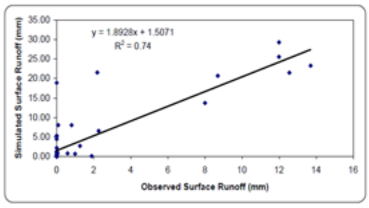

Fig. 7 (b): Comparison of weekly observed and simulated surface runoff hydrograph during validation (2002)

The comparison of monthly observed and simulated surface runoff hydrograph during validation (2002) is shown in Fig.8 (a) and 8 (b).

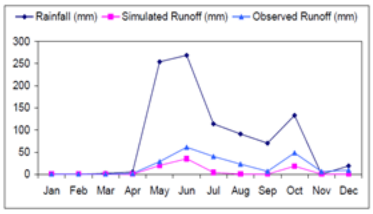

Fig. 8 (a): Comparison of monthly observed and simulated surface runoff hydrograph during validation (2002)

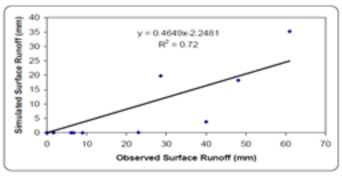

Fig. 8 (b): Comparison of monthly observed and simulated surface runoff hydrograph during validation (2002)

For the year 2013 the simulated runoff was 505.61 mm as against the observed runoff of 397.95 mm out of a total rainfall of 915.9 mm. Daily comparison showed a correlation of R2=0.47 between observed and simulated runoff as the model over predicted the daily observed values during most of the peak flows.

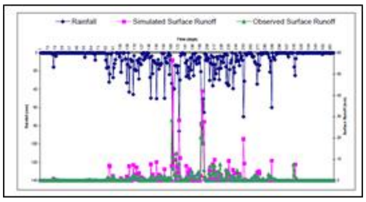

Fig.9 (a): Comparison of daily observed and simulated runoff hydrographs during validation (2013)

However the model efficiency was reported to be very good (R^2 NS=0.93). It was however observed that the weekly and monthly comparison of observed and simulated values tends to smoothen the graph (R2=0.79 & 0.90). Validation was also done for weekly and monthly sediment yield for the year 2013. It was observed that the model over predicted the sediment load in most of the events. The R^2 was observed to be 0.35 and 0.19 respectively. The total simulated sediment yield was observed to be 3.88 t/ha/yr as against the observed sediment yield of 2.12 t/ha/yr. The comparison of daily observed and simulated runoff hydrographs during validation (2013) is shown in 9 (a) and Fig. 9 (b).

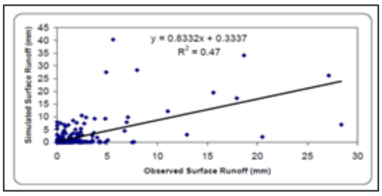

Fig.9 (b): Comparison of daily observed and simulated runoff hydrographs during validation (2013)

The comparison of weekly observed and simulated surface runoff hydrographs during validation (2013) is shown in Fig.10 (a) and 10 (b).

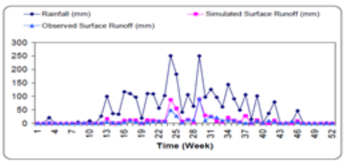

Fig.10 (a): Comparison of weekly observed and simulated surface runoff hydrographs during validation (2013)

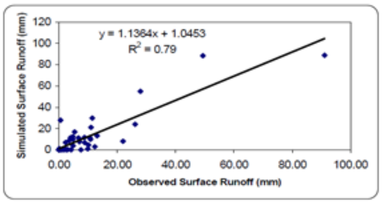

Fig.10 (b): Comparison of weekly observed and simulated surface runoff hydrographs during validation (2013)

The comparison of monthly observed and simulated surface runoff hydrographs during validation (2013) is shown in Fig.11 (a) and 11 (b).

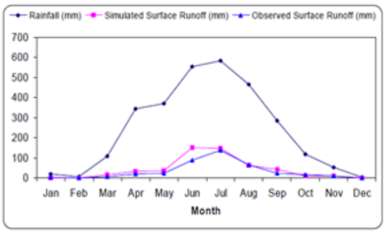

Fig.11 (a): Comparison of monthly observed and simulated surface runoff hydrographs during validation (2013)

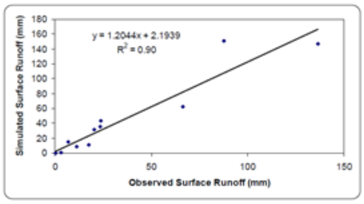

Fig.11 (b): Comparison of monthly observed and simulated surface runoff hydrographs during validation (2013)

The comparison of weekly observed and simulated sediment yield during validation (2013) is shown in Fig.12 (a) and 12 (b).

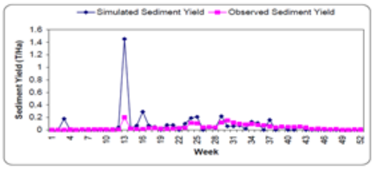

Fig. 12 (a): Comparison of weekly observed and simulated sediment yield during validation (2013)

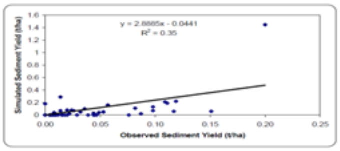

Fig. 12 (b): Comparison of weekly observed and simulated sediment yield during validation (2013)

The comparison of monthly observed and simulated sediment yield during validation (2013) is shown in Fig 13 (a) and 13 (b).

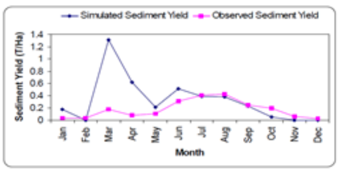

Fig.13 (a): Comparison of monthly observed and simulated sediment yield during validation (2013)

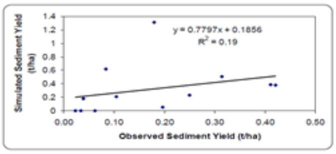

Fig.13 (b): Comparison of monthly observed and simulated sediment yield during validation (2013)

The Evapotranspiration was also simulated by the AVSWAT model using the Penman –Monteith method. The ET was observed to be maximum during the month of May (96.59 mm) and minimum in the month of December (13.85 mm).The weekly and monthly distribution of simulated ET and PET are presented in Fig. 14 and 15

Fig.14: Graph showing weekly distribution of PET and ET

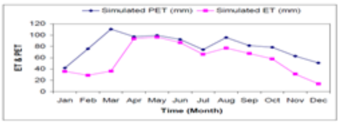

Fig.15: Graph showing monthly distribution of PET and ET

VII. CONCLUSION

1) Validation of the model was done for the year 2002 and 2013 using the climatic data for both the years. Model calibration and validation performance between the observed and simulated surface runoff and sediment data were evaluated using graphical and statistical methods.

2) Graphical and statistical methods revealed an R^2 value of 0.68, 0.75 and 0.82 for daily, weekly and monthly results for surface runoff and 0.36 for monthly sediment load during calibration period.

3) The Nash-Sutcliffe R^2 NS for daily, weekly and monthly surface runoff were found to be 0.53, 0.52 and 0.56. During the validation period R^2 values were observed to be 0.43, 0.74, 0.72 (2002) and 0.28, 0.79 and 0.90 (2013) for daily, weekly and monthly results for surface runoff with Nash-Sutcliffe R^2 NS efficiency of 0.93. Simulated weekly and monthly sediment data showed a poor correlation (R^2=0.35 and 0.09) while compared with the observed sediment data.

4) The model using the Penman–Monteith method also simulated Eva-potranspiration. The impact of land use/ land cover on surface runoff and sediment yield was also studied based on the monthly simulated and observed values of 2002 and 2013. The annual total runoff estimated was 77 mm for year 2002 from 957 mm of rain (a high rainfall year) and 505 mm for year 2013 from 915 mm rain (a low rainfall year).

5) From the statistics of this two year it is clear that the two year comparison effect of forest is not discernible due to large variation in input i.e. rainfall. Thus, a simulation study, with 2013 rainfall that is around 45% higher than climatic mean (2000 mm) for Bhima basin was carried out for both the year. The result indicates that in 2002 the simulated runoff was 488mm and due to deforestation it has increased to 505 mm. Similarly sediment yield increased from 2.41t/ha/yr 3.88t/ha/yr. From the analysis of these results we can conclude that land use/ land cover has got an impact on the surface runoff and sediment load.

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