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Assessment of Sedimentation by GIS- A review

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***Abstract*— The flow of river brought sediment particles originate from soil erosion processes in catchment. When this flow of water stored in reservoir, sediment settles in reservoir which results in the reduction of storage capacity, cover fish spawning grounds, clog drainage canals and passage and reduce downstream water quality. Hence estimation of sediment deposition becomes very important for river morphology, conservation planning of water and soil, design of erosion control structure and proper management and working of reservoirs. Certain Conventional methods such as, hydrographic surveys, inflow and outflow approaches, are used for estimation of reservoir sedimentation. But these methods are inconvenient, expensive and time consuming. So simple methods should be develop, which is less time consuming and economical. This study is an effort of assessment reservoir sedimentation and loss of capacity of reservoir by geographic information system (GIS). The study is based on detailed study and anatomization of some papers written by various popular researchers in this field.**

***Index Terms*— GIS, sediment delivery ratio Sediment yield, Trap-efficiency.**

I. INTRODUCTION

Water is one of very important substance for every creature present on earth, All animals and plants must need a water for survive. Water is indeed component for socio-economical development, growth, farming, industrialization and poverty reduction (Bhavsar m 2015). The smallest sector for its fastest growth rate, increase its demand of water will be on the peak by 2035 (google2015). The next 30 years are daring to build hydropower stations, the higher food production at lower rate of water consumption, development of Industrial and Agriculture sector and the economical waste water treatments (Lin at. al. 2012, Mukherjee at. al. 2007, and Ranga Raju at. al. 2002). Available resource of water should be use in optimizing way as reservoir build on rivers are continuously filling by sedimentation (Kothyari u c and Jain **s** k 1997). A

very large quantity of sediment is transported annually by Indian rivers down to the reservoirs, lakes, bays, and oceans (Jain at. al. 2010). Erosion of soil is mainly due to rainfall and winds, which resulting in tremendous movement sediment into water courses by flood and storm waters (Mishra A at.al. 2007, Pandey A at.al. 2008, and Jain at. al. 2010). Deposition of coarse sediments reduces the reservoir storage and channel conveyance for water supply, irrigation and navigation and causes extensive disturbance to streams (Seth at. al. 2003, Singh at. al. 2007, and Bhavsar m 2015). Suspended sediments cause turbidity, which affects the biotic life in reservoir. Settlement of sediments to the bottom of water bodies bu**ries** and kills the vegetation and changes the ecosystem (Rao K.S. at. al.2002, Sharma at. al. 2006, Bhattarai R & Dutta D 2007, Lin at. al. 2012). In order to determine the useful life of a reservoir, it is essential to periodically conduct the surveys and assess the sedimentation rate in a reservoir (Ijam and tarawaneh 2012). Also, for proper allocation and management of water from a reservoir, knowledge about the sediment deposition pattern in various zones of a reservoir is essential (Borland & miller 1958, Narayana D & Babu R 1983, Mishra A and Froebrich J 2007).

II. LITERATURE REVIEW

Reservoir is the very important and valuable hydraulic structure for storage of water so that this resource can be used for vast area of society and different aspects. And the capacity of reservoir is continuously reducing due to entering of eroded soil carried by water, wind, ice and movement of particles due to gravity force. A huge quantity of sediment is deposited annually by Indian rivers in lakes, reservoirs, estuaries, bays and oceans. Loss of storage capacity due to reservoir sedimentation affects both obtains ability of water and operation schedules

Kothyari and Jain (1997) studied of Karso catchment in Bihar, India give a method for estimation of sedimentation yield from catchment area by using GIS method. In this method they uses spatial Disaggregate of the catchment into cells having monotonous soil erosion properties .The erosion from surface of each discretized cells is routed to the catchment outlet using the help of sediment delivery ratio, which is defined as a ratio of sediment yield to total surface erosion. The total sediment yield of catchment is a sum of individual sediment given by each cells. The spatial disintegration of catchment and essential properties of erosion from each cell is computed by GIS technique by using the Integrated Land and Water Information Systems (ILWIS) package. In this study sediment yield estimation can be grouped into two categories: (i) physically-based models; and (ii) lumped models. In this paper auther use USLE method, The USLE method was expressed by Williams & Berndt (1972) as:

$$S' = R\text{-}KL\text{-}S\text{-}CP$$

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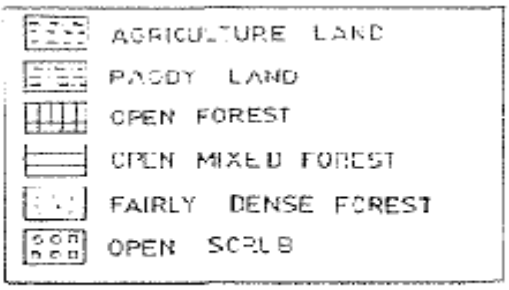
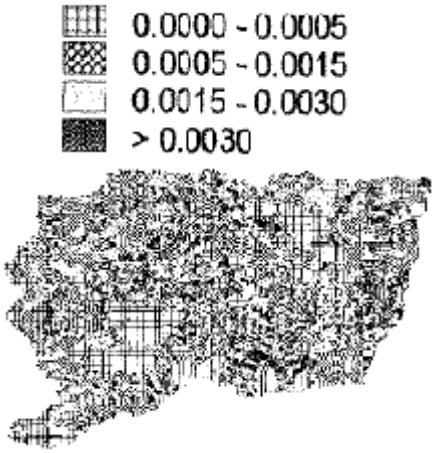


Land-use map of the study area.

Its Concluded that satisfactory results were achieved when the proposed method was used for the determination of sediment yield for various storm events in above catchment. The method based on calibration against a record of existing conditions and hence it can be used for the estimation of sediment yield in other such ungauged catchments which have similar hydrometeorological and land use conditions.

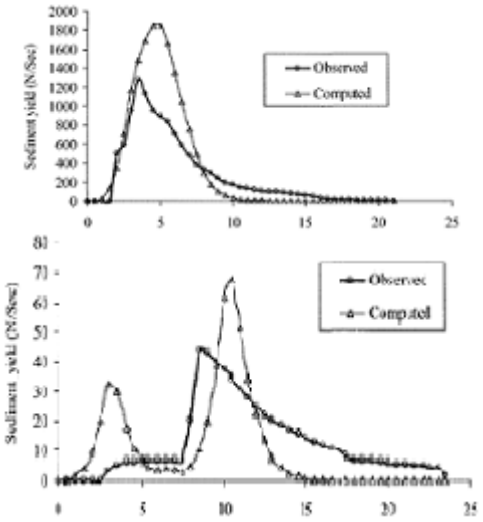
Kumar and Kothyari (2000) in their study gives and confirmed Geographical Information System (GIS) based technique for the determination of sediment source areas and the estimation of storm sediment yield from catchments. The Integrated Land and Water Information System (ILWIS) GIS package and Earth Resources Data Analysis System (ERDAS) Imagine image processor has used for geographic analyses and the digital analysis of satellite data for deriving the land cover and characteristics of the catchments soil. The total sediment yield of each homogeneous grid cells of catchment during isolated storm events are found by Universal Soil Loss Equation (USLE) by carefully determining its various parameters and by the concept of sediment delivery ratio (SDR)



Soil erosion potential maps of the Nagwa catchment

After providing values to the various parameters of the USLE in different cells, their gross surface erosion is calculated and satisfactory results were come out for storm sediment yields on the Nagwa and Karso catchments by using the proposed method.

Ranga raju at. al. (2002) has given research on a temporal variation of sediment deposition during isolated storm events by using data of Karso and Nagwa in Jharkhand with the help of ILWIS GIS tool, which divide catchment into cells and give variation of topographical characteristics and land use. The Unit sediment graphs for the catchments were derived by conversion of the sediment yield from the grid cells and dispels through a linear storage reservoir.



Comparison between observed and computed temporal variation of sediment yield: (a) Nagwa catchment for the 6 July 1989 event;
(b) Karso catchment for the 3 August 1991 event

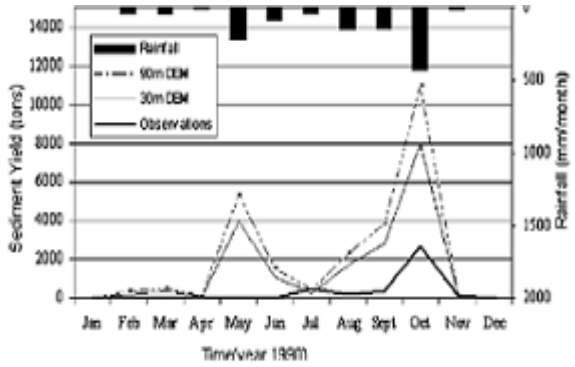
The total sediment deposit yield for the storm duration is also determined by the recommend method. Output values of the storm sediment yields are found to compare well with their corresponding observed values.

Jain at. al. (2003) studied of sediment yield in Satluj River which has flow in western Himalayan region has proposed two approaches for the assessment of sediment yield for three years (1991-1993), first based on relationship between suspended sediment load and discharge, for Satluj Basin up to Suni and intermediate basin between Kasol and Suni, second method which gives annual sediment yield, has been used for a small intermediate basin only because of data availability constraints, which is empirical relationship, both are GIS based technique. It was concluded that for relationship between sediment yield and discharge at Suni, Kasol and for the intermediate basin, a reasonably good result was found between estimated and observed data for these two years for the basin at Suni, Kasol and for the intermediate basin. When empirical relationship was used, results showed that sediment yield was significantly underestimated because developed equation was based on parameter of plain regions and the study is carried out in mountainous region. So the equation was revised using the basin parameter of mountain and after that the estimated value of sediment yield is found to be close to the observed value.

Mishra et al (2005) in their research proposed new model for estimation of the rainstorm-generated sediment yield from (98 storm events) obtained from 12 watersheds of different land uses by combining soil conservation service curve number (SCN-CN) method with the universal soil loss

equation (USLE). Three hypotheses are made for coupling, (1) runoff coefficient is equal to the degree of saturation, (2) the potential maximum retention can be expressed in terms of the USLE parameters, and (3) the sediment delivery ratio is equal to the runoff coefficient. They concluded that the estimation of direct runoff and sediment yield by using rainfall data and watershed characteristics will be enabled because of the hypothesis C=Sr=DR and the sediment yield and runoff, respectively, with efficiencies of 91.78 and 91.75% are found.

Bhattarai & Dutta (2006) has done study to determine soil erosion and sediment yield in a small watershed in Mun River basin, Thailand by using GIS technique. The spatial disaggregation of catchment area into uniform cells is done to get the sedimentation by using USLE along with determination of sediment delivery ratio and various parameters. The effect of DEM resolution on sediment yield is analyzed using two different resolutions of DEM.



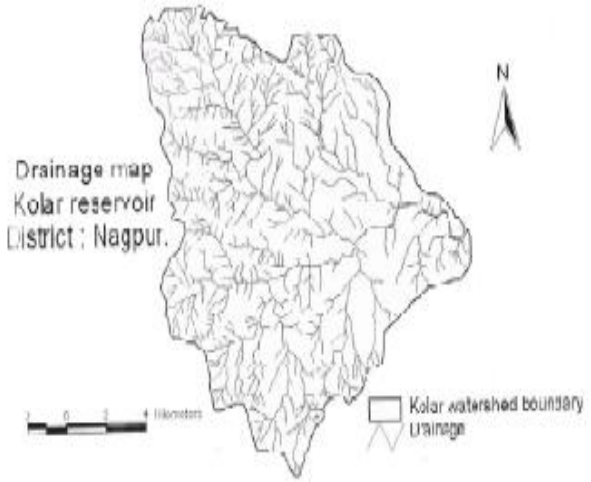
Results shows computed and observed values are observed to have some discrepancy for both annual and monthly sediment yield because the assumptions made during the analysis (soil erodibility value (K) and cover management factor (C)) and Better accuracy of estimates of sediment yield are achieved using 30 m DEM than 90 m because of the effect of DEM resolution on different USLE parameters (L, S factors and Sediment Delivery Ratio (SDR)).

According to *Mishra at. al. (2007)* in their study, a GIS based model, Soil and Water Assessment Tool (SWAT) is used to determine sediment transport from the 17 km2 Banha watershed located in northeast India. This has property of mixed land use and on on-stream sediment control structures called checkdam. By simply comparing observed data and measured data, a calibration (1996) and validation (1997-2001) of surface runoff and sediment yield is performed with SWAT model on both a daily and monthly basis. Calibration and validation of the SWAT model is performed with and without check dams to test its ability in visualizing the impacts of sediment control structures in the watershed. The model shows that loss of sediment from the watershed could be decreased more than 64% by acquiring check dams as a barrier for sediment.

Singh, et al. (2007) in their research, runoff and sediment yield of a small multivegetated watershed in a sub-humid subtropical region in India is estimated by the Soil and Water Assessment Tool (SWAT) model and are compared with measured data. Following values of the correlation coefficient between rainfall and runoff is 0.86, that between runoff and sediment yield is 0.56, and that between rainfall and sediment yield is taken as 0.55. The average estimates of sediment yield from different sub-watersheds will used to design the checkdam construction as an effectual measure to control sediment transport to downstream site. They concluded that the sub watersheds, which has high forest cover (SWS1 and SWS2) shows significantly less runoff and sediment yield (310.36 mm and 0.84 t/ha), but in sub-watershed with more area under cultivation produced higher runoff (393.5 mm) and higher sediment yield (11.65 t/ha).

Pandey et al. (2007) in their research paper shows the WEPP (Water Erosion Prediction Project) watershed model, which is using for calibration and validation for a small hilly watershed (Karso) of India. The model for calibration use data from the 1996 monsoon season and later its performance will evaluated by estimating the daily runoff and sediment yield using the monsoon season data of different years. Various parameters like Coefficient of determination (R2) (0.86–0.91), Nash–Sutcliffe simulation model efficiency (0.85–0.95), and percent deviation values (7.90–15.15) is used for indicating accurate simulation of runoff from the watershed. However the higher values of (R2) between 0.81 to 0.95, Nash–Sutcliffe efficiency ranging from 0.78 to 0.92, and percent deviation from 4.43 to 19.30 indicated satisfactory simulation of sediment yield. They concluded that the variation in each of the parameters by ±50% in a run exhibited the sediment yield to vary from 1.24% to 17.90% and 1.25% to 11.15%. Previously the WEPP model are not predicting erodibility parameters satisfactorily in both surface runoff and sediment yield simulations in pre-calibration because of the empiricism involved in model equations. But now the calibrated model results could be of use in erosion based watershed.

Chitade and Tiwari (2008) has carried out study and presents the technique for assessment of sediment yield at Kolar catchment area of Nagpur district Maharashtra state India using Geocoded Remote Sensing satellite image IRS-LISS-III for geometric correction, land-use land cover map of the area and geographical information system for preparing drainage map, contour map and slope map. The meteorological data such as average annual rainfall and mean annual temperature will be use for calculating amount of sediment yield in the reservoir. The value of sediment yield per Km2. is found to be 241.37 M3 per Km2 per Year which is higher than the value of 238.16 M3 per Km2 per Year which is used for designing of the reservoir.



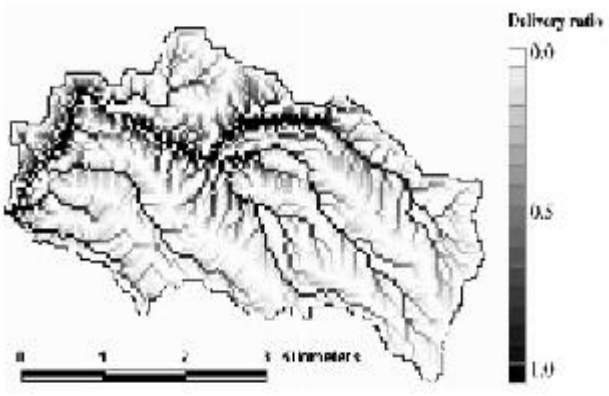
DRAINAGE MAP

Tyagi at. al. (2010) has studied an area of Suni to Kasol, an intermediate watershed of Satluj river, located in Western Himalayan region for estimation of runoff and sediment yield by using the Soil and Water Assessment Tool (AVSWAT) having an interface with Arc View GIS software (AVSWAT2000/X).Calibration of model has been done for the years 1993 & 1994 and validated with the observed runoff and sediment yield for the years 1995, 1996 and 1997. Model's performance was evaluated using statistical and graphical methods to estimate the capability of the model in simulating the run-off and sediment yield from the study area. It was founded that the coefficient of determination (R2) for the daily and monthly runoff is obtained as 0.53 and 0.90 respectively for the calibration period and 0.33 and 0.62 respectively for the validation period. The R2 value in estimating the daily and monthly sediment yield during calibration is computed as 0.33 and 0.38 respectively. The R2 for daily and monthly sediment yield values for 1995 to 1997 is found to be 0.26 and 0.47. Now the values of R2 can be considered reasonably satisfactory for estimating runoff and sediment yield for the watersheds.

Vemu and Pinnamaneni (2012) carried study to estimate sediment yield at the outlet of river Indravati catchment by using USLE. Both spatial distribution and magnitude of potential soil erosion in the catchment will be determined by using GIS and remote sensing. For study purpose Indravati basin will divided into 424 sub-watersheds and prioritization of all 424 sub-watersheds will be carried out according to soil loss intensity for soil conservation purpose. it founded that average erosion rate predicted is 18.00 tons/ha/year and sediment yield at the out let of the catchment was 22.31 Million tons per year and 19.71 % of the area is undergoing high erosion rates which will be a major contributor to the sediment yield (78.04 %) in the catchment. Generated soil loss map will be able to indicate high erosion risk area which will be helpful to soil conservationist and decision makers. Finally it was concluded that the actual sediment yield at the outlet is likely to be less than the estimated.

Ijam and tarawaneh (2013) presented soil and water assessment tool (SWAT) in association with GIS to simulate the hydrology, soil erosion and sedimentation of wala dam catchment (2000 Km2) in Jordan. The calibration(1972-1979) and verification(1990-1998) of a result is carried out in their work by using flow rate and sediment yield data observed in wala catchment and the results obtained by this is satisfactory and acceptable. The predicted result of average sediment yield is found to be 143780 ton/year and 123100 ton/year is for predication periods. It was founded that the northern and western part of wala catchment receive maximum amount of rainfall, hence generated large amount of runoff volume to stream, are more susceptible for soil erosion and give large amount of sedimentation yield to wala catchment. Hence the study suggested that the present model with its corresponding set of parameter is able to estimate water flow and sediment yield. So it can be used for future planning and management.

Lin and Chou(2014) has presented determination of sedimentation by using GIS coupled with the universal soil loss equation (USLE) or agricultural non-point source pollution model (AGNPS). Soil erosion is a very complex and heterogeneous hydrological process. This method had widely used to calculate erosion at any point in a landscape that experiences net erosion. In this method DEM play a important role by provide input for spatially distributed models and can provide primary spatial information on elevation, slope and watershed aspect in the modeling process. It was conclude that the average annual sediment yield is found to about 2.35 × 106 t measured at a sampling station with a watershed area of 645.21 km2. A 2.6mm average annual deposition depth can be derived from the 1.4 t/m3 bulk density calculation.



Sarita Gajbhiye (2015) carried out study in Kanhaiya nala watershed situated in Satna district of Madhya Pradesh by using remote sensing and GIS. The total watershed area was 19.53 km^2. GIS was used for generating Soil map, Land Use and slope. The used curve number method is taken as a distributed model, by it we can get information dealing with a large number of sub-catchments in the basin. Therefore we used remote sensing and GIS techniques. Landsat (ETM) satellite images were used to get land cover information by ERDAS 9.1 software. The important layers like soil map, elevation map, rainfall map and land cover map are created in Arc GIS 9.3. Finally they concluded the capacity loss of 9.65.76% in 35 years.

III. . CONCLUSION

Various regions of India and also outside the country are considered in this review of assessment of sedimentation. Along with different types of terrains like semi-arid region, sloping region, flat and hard rock are studied. To study about the sedimentation of the reservoir many research papers, articles, reports and books have been studied as motioned above, it is found that modern GIS technique is good for estimation of reservoir sedimentation as compared to conventional method which seems to be more tedious and time consuming because of the long procedure and complicated equipment requirement. This methods give results in short period of time, hence continues records can be obtained. The various software tools of GIS used for assessment of sedimentation are **ILWIS, Accumplus, SWAT, AGNPS, WEPP, USLE, RUSLE, Arc GIS, EASI/PACE** are used. Determination of sedimentation by GIS technique is easy, economical, time saver and faster. So it is the best way of doing short time study with lack of data, manpower and hard manual work.

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