Review on Study of Reservoir Sedimentation by Remote Sensing Technique

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Abstract

Sediment particles originating from soil erosion processes in the catchment are propagated along with the river flow. The sediment settles in the reservoir, when the flow of a river is stored in a reservoir and reduces its capacity. Reduction in the storage capacity of a reservoir beyond a limit hampers the purpose for which it was designed. Hence assessment of sediment deposition becomes very important for the management and operation of such reservoirs. Some conventional methods, such as hydrographic survey and inflow outflow approaches, are used for estimation of sedimentation in a reservoir, but these methods are cumbersome, time consuming and expensive.There is a need for developing simple methods, which require less time and are cost effective. Present study, is an attempt to estimate reservoir sedimentation and capacity loss by using Remote Sensing Technique. This study has been done by a detailed research and analysis of some papers written by well known researchers in the above field.

Keywords: Sediment, Storage Capacity, Remote Sensing Technique

I. INTRODUCTION

Water is essential for socio-economic development and for maintaining healthy economic component of growth, poverty reduction and equality. The livelihood of the poorest sector with higher rates of urbanization, increasing demand for drinking water will put stronger by 2030. The next 25 years are challenging to create hydropower stations, the higher food production at lower rate of water consumption, development of Industrial and Agriculture sector and the economical waste water treatments.

Water Resources Management aims at optimizing the available natural water flows and competing needs. Adding uncertainty, climate change will increase the complexity of managing water resources. The mounting challenges due to demand and supply of water, It becomes essential to utilize available storage in minimize rate. It is well established fact that reservoirs constructed on rivers are subjected to sedimentation. Reservoir sedimentation is a natural phenomenon. All the reservoirs are bound to suffer a loss in their storage potential because of silt load, over a period of time.

A great amount of sediment is carried annually by Indian rivers down to the reservoirs, lakes, estuaries, bays, and oceans. Soil is eroded due to rainfall and winds, resulting in tremendous sediment movement into water courses by flood and storm waters. The impact of sediment erosion, transport and deposition is widespread. Deposition of coarse sediments reduces the reservoir storage and channel conveyance for water supply, irrigation and navigation and causes extensive disturbance to streams. Suspended sediments reduce the water clarity and sunlight penetration, thereby affecting the biotic life. Settlement of sediments to the bottom of water bodies buries and kills the vegetation and changes the ecosystem.

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. 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. With the correct knowledge of the sedimentation processes going on in a reservoir, remedial measures can be undertaken well in advance and reservoir operation schedule can be planned for optimum utilization of water.

For assessing the sediment deposition pattern in a reservoir, systematic capacity surveys of the reservoir are conducted periodically. Present conventional techniques of sediment quantification in a reservoir, like the hydrographical surveys and inflow-outflow methods, are cumbersome, costly and time consuming. Remote sensing, through its spatial, spectral and temporal attributes, can provide synoptic, repetitive and timely information regarding the water spread area of the reservoir. With the deposition of sediments in the reservoir, the water spread area at an elevation keeps on decreasing. By comparing the decrease in water spread area with time, the sediment distribution pattern in a reservoir can be determined indirectly. This information can be used to quantify the rate of reservoir sedimentation.

II. LITERATURE REVIEW

Reetesh Katiyar, P. K. Garg, S. K. Jain (2006) in their study divided the catchment for Ramganga into nine sub watershed to determine the sub-watershed most prone to soil erosion.

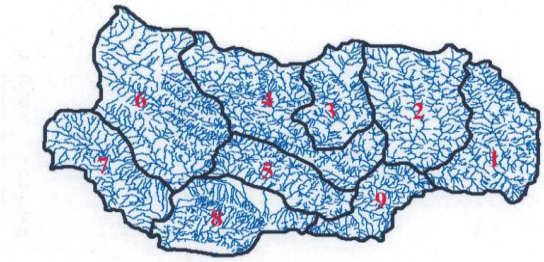

Fig. 3: Drainage Network of Nine Sub-catchments of Ramganga reservoir

Topographical maps are digitized for preparing contour map and drainage network. By drainage network, delineation of catchment and sub catchment is done and then by generating slope and water pixels from satellite images, sub-catchment contributing to max soil erosion is determined. Also through temporal IRS-1B LISS-III images between 2000 and 2001 are used on ILWIS image processing and GIS software for assessment of reservoir sedimentation. Conclusion derived from the study says that the Remote Sensing gives good accuracy for determining sediment rate.

Saumitra Mukherjee, et. al. (2007) studied satellite data of Hirakund Reservoir for five optimal dates corresponding to various water stages from minimum to maximum draw down levels were used in estimating water spread areas. Through this (NIR/RED) image were generated to indentify water pixels and thus verifying standard FCC. The non water pixels were indentified with Ratio (GREEN/NIR) image and were removed from total water-spread. By correlating the data from the water-spread area and corresponding derivations, total reservoir storage capacity was determined with the help of elevation area curve.

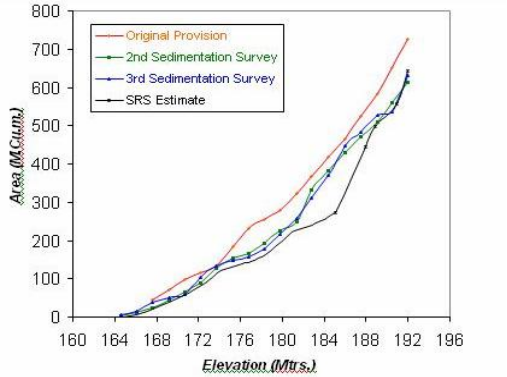

Fig. 2: Updated Elevation-Area Curves for Hirakund reservoir

Kamuju Narasayya, U C Roman, S. Sreekanth and Sunneta Jatwa (2012) in their research paper, assessment of sedimentation was carried out for Srisailam Reservoir using remote sensed satellite imageries. The area capacity curve of the year 1976 was taken as a base for assessment for year 2004. Three types of data were collected (i.e. topographical data, Satellite data and field data). For topographical data contour map and toposheet were collected for base-map creation. Satellite date for IRS 1C, 1D and P6 for LISS-III sensor were collected from NRSC. The field data were collected from local irrigation office as well as dam site. By geo-referencing and data obtained from satellite through NRSC and field data, interpretation and estimation of water-spread area was done by EASI/PACE software. Comparing the result with base period of field data sedimentation rate was calculated. The research paper concluded that a definite relationship exists between reservoir shape and percentage of sediment accumulated in various depths since its impoundment.

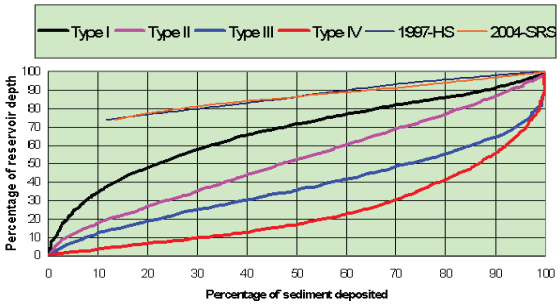

Fig. 3: Sediment Deposition Pattern in Srisailam Reservoir for Different Years Superimposed on Borland and Miller curves

S.R.Mandwar, Dr. H.V. Hajare et. al. (2013) in their research paper has done a case study of Totla dam for capacity evaluation and sedimentation. The basic concept was to find out the water-spread area from satellite data for different water level between MDDL and FDL. From water-spread area reservoir capacity is calculated and compared with previous surveys. And hence estimation of live capacity loss due to sedimentation was determined. Certain limitations were concluded for satellite remote sensing.

- Remote sensing based capacity estimation work between FRL and minimum water level in reservoir only.
- It gives accurate estimation for fan shaped where there is considerable change in water-spread area for incremental change in water level.

Issa E. Issa, et. al. (2013) In their paper two topographic maps of Mosul reservoir dated 1983 and 2011 in "Triangular Irregular Network" were used for the calculation of sedimentation rate and determining the reduction in storage capacity for live and dead storage as well as whole Mosul reservoir during its operational period. The TIN maps were used to compute the storage capacity and water-spread area for live storage and dead storage using Arc/GIS software. The reduction in storage capacity of the reservoir for the two surveys at different time represents total volume of sediment accumulated and reduction in water spread area for reservoir.

Furthermore, two surveys were used to determine the future shift in the stage storage capacity curve of reservoir. Also the observed results and algebraic equation that were proposed by Gill were used to determine the life span of Mosul reservoir.

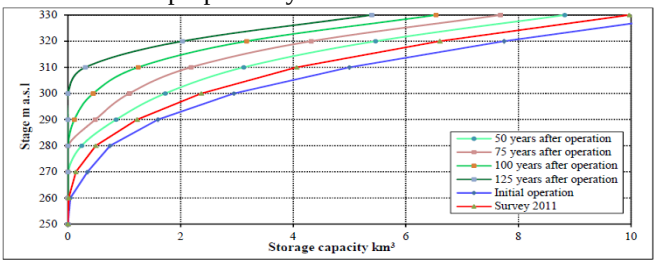

Fig. 4: Stage-storage capacity curves for Mosul reservoir.

Sanjay K. Jain, Pratap Singh, S. M. Seth (2002) in this research paper, study was carried out for sedimentation in Bhakra reservoir. Here satellite data were processes and using ERDAS/IMAGINE 8.3.1 software for determining the water spread area in reservoir. Initially a false colour composite (FCC) of the satellite data was prepared and visualized, the image of October was considered as the master image and eight control points were selected for image to image registration. Based on statistics, the points which generated big errors were deleted and replaced by others points to obtain satisfactory geo-referencing. Images were overlaid and comparison was done. For the same period under study, ground observation survey provide sedimentation rate.
Hence by plotting elevation capacity curve for both SRS and hydrographical survey, it was concluded that SRS proves accurate for short intervals. They concluded some limitations for remote sensing for example it gives information on capacities only in water level fluctuation zone, which generally lies in live zone of reservoir.

M. K. Goel, Sharad K. Jain & P. K. Agarwal (2002) a case study related to the assessment of sediment deposition in Bargi reservoir, Madhya Pradesh state is presented in this paper. The images of nine date from IRS-1C satellite, LISS-III sensor had been analyzed using ERDAS/IMAGINE software. The period from October 1996 to June 1997 was selected for analysis. The multi-spectral remote sensing images were first geo-referenced to as master plan. Using the geo-referenced images the water – spread areas at different time periods were compared and revised contours were overlaid. The drainage pattern of area around and within the reservoir water-spread was digitized from 1:50000 scale toposheets of the Survey of India. Image to image registration was carried out for all images. Each image was geo-referenced with its subsequent date image. After this, the resulted images were geo-referenced with drainage map. After this, the resulted images were geo-referenced with drainage map. Thus after removal of discontinuous water pixels and extended tail and channels, revised contours was derived. Hence calculate revised capacity of the reservoir.

Certain points were concluded by the researcher form the study done which refers the accuracy in estimation of sedimentation by remote sensing are.

- It is highly sensitive to determine water spread area
- Sensitive to water level information
- Original elevation area capacity table.
- Accuracy in identification of water pixels.

Asif M. Bhatti, Seigo Nasu and Masataka Takagi (2011) took prime objective of this research work to calculate suspended sediment concentrations in surface waters by means of ALOS and ASTER satellite data. Here the multispectral data and optical modelling is integrated to cope with lack of ground truth data. The combination of ALOS/AVNIR-2 band 3 and 4 was selected to demonstrate the relationship between reflectance and suspended sediment concentration. Data were collected for annual sediment load, discharge, sediment type and other water quality data, also features of dam, etc. Image processing, atmospheric correction and spectral analysis was carried out and hence researchers developed a model. By this model, they developed a SS monitoring system for dam/reservoirs. The usefulness of this research is to make possible to work with minimum data with high reliability and efficiency.

M.K.Goel, Dr. S.K.Jain, P.K.Agrawal (1997-98) in this report, the sediment deposition pattern within a zone of Ukai reservoir had been determined using remote sensing techniques.

Remotely sensed data of eight different dates had been obtained for year 1993-94 of IRS-1B satellites and LISS-II sensor from NRSA. Water spread areas were extracted using ERDAS/IMAGINE software. The original elevation-area-capacity curves and reservoir levels for eight dates of satellite pass were obtained from dam site. Using trapezoidal formula, the revised capacity between maximum and minimum observed levels was obtained. Thus the loss of capacity was observed which was due to sediment deposition. Results were compared with hydrographical survey of 1992-93, which came closer to obtained results.

Roman, Uday C. Suneeta, Jatwa, et. al. (2010) in their paper described the assessment of sedimentation using SRS technique, for Ujjani reservoir on river Bhima, in Solapur district of Maharashtra state of India. The water spread area of reservoir at different water levels between FRL and MDDL IN different month of year were computed from satellite imageries. New elevation-capacity curve would be established and compared with availability of imageries from IRC 1C, 1D and P6 satellites using LISS-III sensors. And hence by comparing both original and revised curve, capacity loss was estimated.

III. CONCLUSION

The above review included various regions in India and also outside the country. Also different terrains like semi-arid region, sloping region, flat and hard rock are studied. The hydrographical survey is very costly, cumbersome and time consuming. Also it cannot be carried out at small intervals. Thus continuous results of sedimentation cannot be obtained. To overcome this problem, an advanced technique of remote sensing can be used for the assessment of sedimentation of a reservoir. This method can be used for analysis of short intervals also and hence a continuous record can be obtained. Also this technique is easy, time saving and economical. Different software like ERDAS/IMAGINE, ALOS and ASTER, Arc GIS, EASI/PACE are used. Images of IRS 1A, 1B, 1C, 1D AND P6 for LISS-III, LISS-II sensor and LANDSAT images are used for interpretation. Thus study of semi-arid region for sedimentation is very important. As there is lack of ground data available, Remote Sensing Technique is applicable and most useful.

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