Sediment Assessment of UJJANI Reservoir in Maharashtra by using Remote Sensing Technique

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Abstract - *Reservoir sedimentation is vital problem as every reservoir are bound to suffer a loss in their storage capacity potential because of silt load, for short or long period of time. For water resources planning and land & water management system, computation of soil erosion, sediment conveyance and its deposition in reservoir should be taken as top priority. Some conventional methods, such as hydrographic survey etc. are used for estimation of sediment deposition, are cumbersome and time consuming. Therefore Remote Sensing approach, which provide high-resolution synoptic and repetitive information with short time intervals on a large scale, requires less time, has been attempted in this study for assessment of sedimentation of Ujani Reservoir, located on the Bhima River in Maharashtra. Multi date remote sensing data i.e. Landsat-7 data for the water year 2001-02 is acquired in this study. NDWI approach has been applied for identification of water pixels and water spread area of the reservoir, which is utilized for determination of sedimentation rate. The revised capacity evaluation of the reservoir is carried out. Revised Capacity-Elevation curve is plotted with comparison to the actual curve. Total sedimentation in 34 years is found about 207.822 Mm3 at a rate of 6.65Ha-m/100Km2/Year.*

Key Words: Remote Sensing, GIS, sedimentation, water management, water resources

1.INTRODUCTION

Sedimentation in reservoirs is indeed a matter of vital concern to all water resources development projects. A great amount of sediment is annually carried by the Indian rivers down to the reservoirs, lakes, estuaries, bays and oceans. Deposition of coarse sediments reduces the reservoir storage and channel conveyance for water supply, irrigation and navigation, and causes extensive damage to streams. Sediments flow in the reservoir, due to decrease in velocity, coarser particles settles at the start reach of reservoir and the finer sediments gets deposited along the reservoir bed. Suspended sediment reduces the water clarity and sunlight penetration, thereby affecting the biotic life. Sediment affected reservoirs which are used for hydropower generation have several major detrimental effects which include loss of storage capacity, damage to or impairment of hydro equipment, bank erosion and instabilities, upstream aggradation, loss of water quality, and effect on eutrophication. The major factors responsible for sedimentation include rainfall, soil type, vegetation, topographic and morphological characteristics of the basin. A number of river valley projects have been commissioned in India for domestic and industrial water supply, irrigation, hydropower generation, navigation and recreation. One of the principal factors which threaten the longevity of such projects is the accumulation of sediments in the reservoirs. In order to determine the useful life of a reservoir, it is essential to periodically assess its sedimentation rate. With the update information on sedimentation processes taking place in a reservoir, remedial measures can be undertaken well in advance and reservoir operation schedules planned for optimum utilization of water. Some common techniques to determine sedimentation are inflow-outflow method, hydrographic surveys etc. Both these methods are laborious, time consuming and costly. With the advent of remote sensing techniques, it has become convenient and far less expensive to quantify the sedimentation in a reservoir. The advantage of satellite data over conventional processes includes repetitive coverage of a given area. The remote sensing techniques provide synoptic view of a reservoir in spatial form while surface data collection and sampling gives point information only.

2 Study area:

Ujjani Reservoir, also known as Bhima Dam or Bhima Irrigation Project, on the Bhima River, a tributary of the Krishna River, is an earthfill cum Masonry gravity dam located near Ujjani village of Madha Taluk in Solapur district of the state of Maharashtra in India. Ujjani Dam is the terminal dam on the river and is the largest in the valley that intercepts a catchment area of 14,858 km2 (5,737 sq mi) (which includes a free catchment of 9,766 km2 (3,771 sq mi)). The construction of the dam project including the canal system on both banks was started in 1969 and completed in June 1980. The reservoir created by the dam has a water spread area of 357 km2 (138 sq mi) at the High Flood Level (HFL) and 336.5 km2(129.9 sq mi) at Full Reservoir Level causing submergence of land and houses in 82 villages. The reservoir stretches upstream of the dam to a length of 134 km (83 mi), and the maximum width of the reservoir is 8 km (5.0 mi). The rim of the reservoir periphery measures 670 km (420 mi).

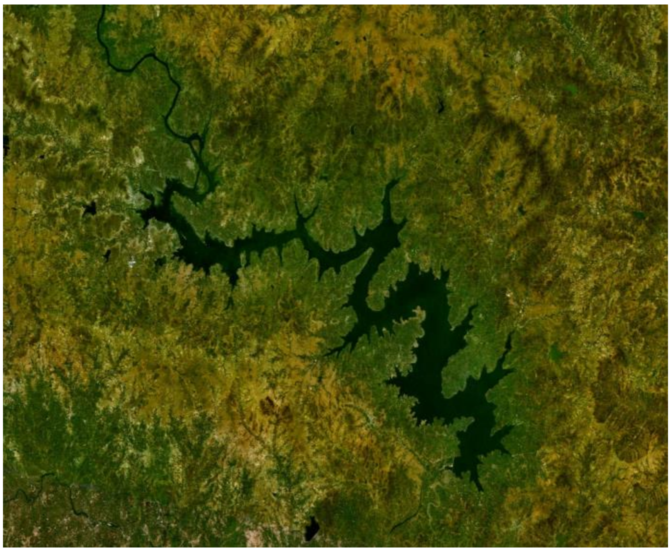

Fig.2.1 Ujjani Reservoir as seen from a NASA satellite

3.1 SATELLITE DATA USED:

In the present study LANDSAT-7 satellite data (resolution 30m) was obtained for the four cloud free dates of water year 2001-02 from USGS website i.e. www.usgs.gov. The data acquired is tabulated as below:

Table 3.1 Specifications of the satellite data

SATELLITE	PATH/ROW	DATE
LANDSAT-7	146-047	27 October 2001
LANDSAT-7	146-047	15 January 2002
LANDSAT-7	146-047	04 March 2002
LANDSAT-7	146-047	08 June 2002

3.2 GROUND BASED DATA

In order for the determination of capacity of reservoir, reduced levels or water levels are acquired for above four dates from Bhima Irrigation Division, Solapur Maharashtra. The data obtained is listed below as:

Table 3.2 Specification of Water level

Date	Water level (in meters)
27 October 2001	493.232
15 January 2002	492.077
04 March 2002	491.282
08 June 2002	488.332

4. Methodology:

In the present study digital analysis was performed out for identifying the water pixels and for determining the water spread area. The various steps followed in the analysis are described below.

4.2 IDENTIFICATION OF WATER PIXEL

Though spectral signatures of water are quite distinct from other land uses like vegetation, built-up area and soil surface, yet identification of water pixels at water /soil interface is very difficult and depends on interpretative ability of analyst. In order to identify water pixels following steps are done.

4.2.1 CONVERSION OF DN TO RADIANCE

The following formula is used to convert DN values in to Radiance values:

$$L_{\_} = ((L_{MAX\_} - L_{MIN\_})/255) * (DN_{\_}) + L_{MIN\_} \text{ ....1}$$

Where, LMAX and LMIN are quantization constants.

4.2.2 CONVERSION OF RADIANCE TO REFLECTANCE

The radiance is converted to reflectance using the below given formula.

$$\rho toa = (Lrad*PI*d^2)/(E0*\cos(90-\text{sun elevation angle})) \text{..................2}$$

where, 'Lrad' (w/m2/ster/µm) is the band radiance; 'd' is Earth –Sun distance in AU (d= 0.997052 for this case), 'E0' = Mean solar exo-atmospheric irradiance for given wavelength in watts/m2/µm/ster (Markham and Barker, 1986)

4.2.3 SURFACE WATER BODIES EXTRACTION USING NDWI APPROACH

McFeeters (1996) developed an index similar to NDVI, which is called as NDWI (Normalized difference water index). Any instrument having green and near infrared band can apply this index. The NDWI is calculated as follows:

$$NDWI = (Green - NIR) / (Green + NIR)$$

Where Green is a band that encompasses reflected green light and NIR represents near infra red radiation. When the above equation is applied to process a multi-spectral satellite image that contains a reflected visible green band and a NIR band, water features have positive values, while soil and other features have negetive values. Image processing software, in present study erdas imagine, can easily be configured to delete the negetive values and then water pixels can be available for analysis.

4.3 ESTIMATION OF WATER SPREAD AREA

Once water pixels for the area of interest is determined i.e in present study, ujjani reservoir, then water spread area at four cloud free dates are estimated utilising the below equation:

Water spread area = No. of Waterpixels * pixel size

Resolution of the satellite image acquired in present study i.e. Landsat-7 has a resolution of 30m. Hence pixel size is 30m*30m.

4.4 STORAGE CAPACITY OF RESERVOIR

The capacity of reservoir between two successive RL or water levels is calculated using Trapezoidal Formula given below as:

$$\text{Volume (V)} = h/3\ [A_1 + A_2 + (A_1 * A_2)^{0.5}]$$

Where, A1 is water spread area at RL (1) and A2 is the water spread area at RL (2), h is the difference between RL or height interval.

5. Results and Discussion:

Following are the results which was obtained after performing the analysis as given below:

Table 5.1 obtained capacity for year 2001-02 by remote sensing

Date	Elevation	Area (Mm2)	Capacity (Mm3)
8 June 2002	488.332	137.71	
4 March 2002	491.282	178.70	259
15 January 2002	493.077	189.69	356.62
27 October 2001	493.232	207.06	509.36

Table 5.2 Designed capacity of ujjani reservoir

Elevation	Area (Mm2)	Capacity (Mm3)
490.26	172.67	59.90
491.39	191.22	275.943
492.36	205.31	482.09
493.36	225.12	717.182

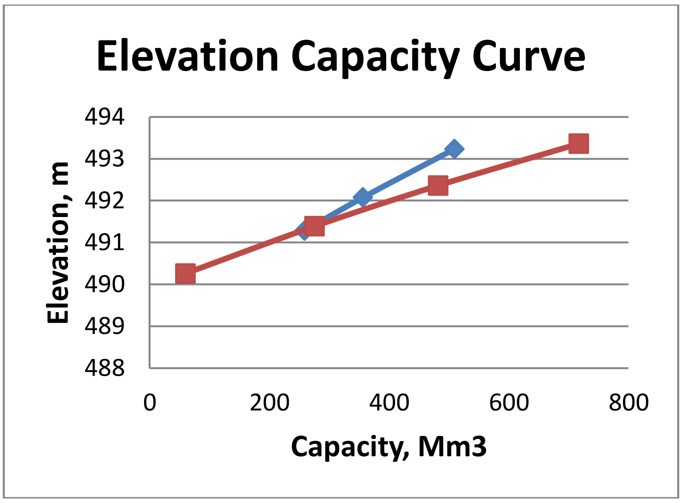

Fig 5.1 capacity elevation curve

6. CONCLUSIONS

Water Spread area for the dates for 27 Oct 2001, 15 Jan 2002, 4 March 2002, 8 June 2002 are obtained by using Remote Sensing as 207.06, 189.69, 178.7, 137.71 Mm2. Total designed Reservoir capacity at RL 493.36 is found out to be 717.182 Mm3 and Reservoir capacity by using Remote Sensing at RL 493.36 in year 2001-02 is found out to be 509.36 Mm3 and annual capacity loss 9.89 Mm3. Rate of sedimentation from the catchment area is 6.65Ha-m/100Km2/Year. So it is necessary to put great concern and take corrective measures in the catchment area to reduce input of silt in the reservoir.

REFERENCES

1) Goel, M.K., Jain, S.K. and Agarwal, P.K. (2002) Assessment of sediment deposition rate in Bargi Reservoir using digital image processing Journal of Hydrological Sciences, 47(5), 81-92.
2) Katiyar, R., Garg, P.K. and Jain Sanjay K.(2006) Watershed prioritization and reservoir sedimentation using remote sensing data, GEOCARTO International, Vol.-21(3).
3) Lishan Ran and X Lu (2012) Delineation of reservoirs using remote sensing and their storage estimate Hydrological Process Volume 26, Issue 8.
4) Mandwar S.R , Hazare H,Vand Gajbhiye A.R (2013) Assessment of Capacity Evaluation and Sedimentation of Totla Doh Reservoir, In Nagpur District By Remote sensing Technique IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) 4(6),22-25.
5) Narasayya .K, Roman1 U.C, Sreekanth.S and Jatwa.S (2012) Assessment of Reservoir Sedimentation Using Remote Sensing Satellite Imageries Asian Journal of Geoinformatics, 12(4), 172-180.

6) Thomas .T, Jaiswal .R.K, Galkate .R.V, and Singh .S (2009) Estimation of revised capacity in Shetrunji reservoir using Remote sensing and GIS J. Indian Water Resource Soc. 29(3), 8-14.
7) Gregory L.Morris, Jiahau Fan, (December 2010) A Hand Book on “Reservoir Sedimentation–Design and Management of Dams, Reservoirs, and Watersheds for sustainable use”
8) Sanjay k Jain (2000) “Assessment of Sedimentation in Bhakra Reservoir Using Remote Sensing”, Hydrology Journal 23.