CAPACITY ASSESSMENT OF EKBURJI RESERVOIR USING REMOTE SENSING

Bhushan Prabhakar Patil[1], Suvasish Mukhopadhyay[2], Pradip Kulkarni[3]

[1] *P.G. Student, Environment and Water Resource Engineering, College of Engineering, Pune.*
[2] *Associate Professor, Civil Engineering Department, College of Engineering, Pune.*
[3] *Sectional Engineer, REC division, Maharashtra Engineering Research Institute(MERI).*

ABSTRACT

The capacity assessment of reservoir is required periodically to determine the useful life of a reservoir due to accumulation of sediments. The conventional method of reservoir capacity survey like theodolite, sextant, sounding rods, echo-sounders and slow-moving boats etc. is laborious, time consuming and costly in comparison to the capacity survey based on satellite remote sensing techniques. The water-spread area of the reservoir reduces with the sedimentation at a given level and this fact is utilized in estimation of reservoir capacity. In satellite remote sensing survey, water-spread area at the time of satellite pass is mapped and used to calculate the incremental reservoir capacity between two levels. With this objective, the present study of the assessment of the sedimentation in Ekburji reservoir is carried out using remote sensing. For that purpose, two satellite images of LISS III and three images of LISS IV of Resource Sat-2 and IRS P-6 satellite are procured from National Remote Sensing Centre along with field data from irrigation department of Ekuburji project and visual interpretation, unsupervised classification of satellite imageries is done using ERDAS IMAGINE 9.3 software to calculate water spread area at Resource Engineering Centre, Nashik. Water spread area will further used to calculate cumulative capacity between different water levels within FRL and MDDL. Results of this survey will further used to compare surveys that will be carried out in future.

Keywords: *Ekburji Reservoir, Erdas Imagine 9.3, Satellite Remote Sensing technique, unsupervised classification*

I. INTRODUCTION

Many reservoirs of large and medium size were designed and built for various plan periods. These reservoirs meet the requirements of nearby community by serving the required water under uncertain monsoon precipitation condition and non-uniform distribution of rainfall. After the dam is built and operated, silt laden water flows into dam causing accumulation of silt in both dead as well as live storage. This results reduction in utilizable water and benefits from reservoir. Life of reservoir is reduced if actual sedimentation rate is greater than designed sedimentation rate (D. S. Rathore et al; 2006). This loss in useful storage capacity due to sedimentation could adversely affect planning for long term utilization of reservoir storage capacity for irrigation, power generation, urban water supply, flood moderation etc.

Various methods like plane table survey, hydrographic survey, sextant, satellite remote sensing technique etc are used to assess the capacity of reservoir. Satellite remote sensing technique gives relatively accurate and quick results, while other conventional methods are laborious and time consuming. The manpower requirement is also considerably less though specialized training may be essential and is independent of the geographical and weather conditions of the site (U. C. Roman et al; 2010). Satellite remote sensing (SRS) technique for capacity assessment uses the fact that the water spread area of reservoir at various elevations keeps on decreasing due to sedimentation (Pankaj Mani et al; 2007). The water spread areas of the reservoir at different water levels between FRL and MDDL in different month of the year are computed from satellite imageries. Knowing the reservoir levels on date of pass of the satellite, existing capacity can be calculated using prismoidal formula and it can be compared with capacity during impounding of reservoir to assess the loss in capacity. (Dilip G. Durbude et al) used the image processing capabilities of GIS software named Integrated Land and Water Information System (ILWIS) to identify dam location and water spread area extraction. Present study is carried out using SRS technique for Ekburji reservoir located at Taluka District Washim of Maharashtra state and Erdas Imagine 9.3 software was used for extraction of water spread area from satellite imageries procured from National Remote Sensing Centre (NRSC).

II. STUDY AREA

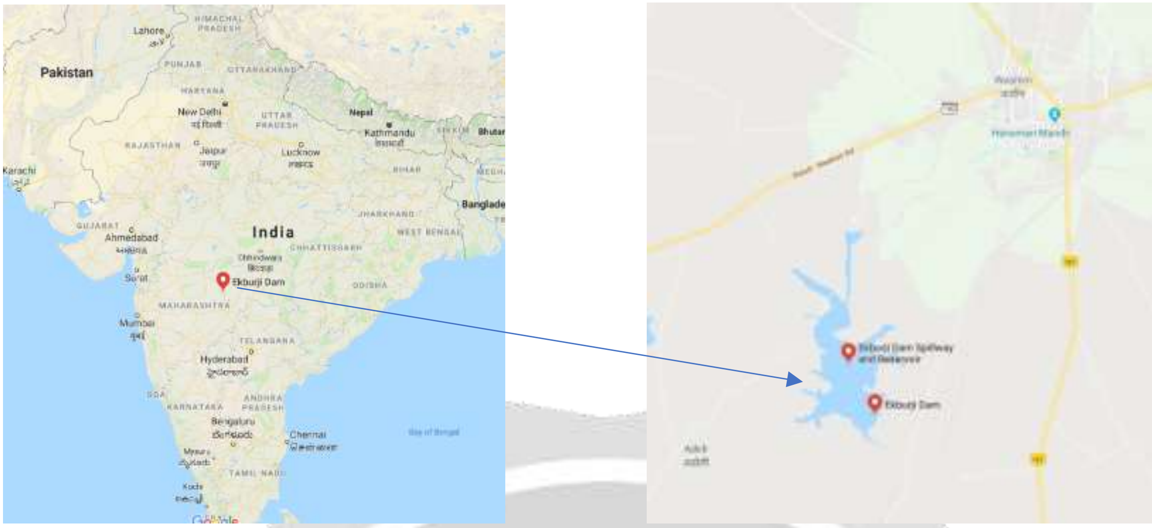

Fig-1: Location of Ekburji Reservoir

The Ekburji reservoir is one of the multipurpose medium projects in Maharshtra. The dam is situated on river Chandrabhaga near Ekburji village of Taluka District Washim in state Maharshtra. The dam is located on 20 06’ 00” longitude and 77 07’ 30” latitude. The catchment area at dam site is about 75.16 km^2. Length of earthen dam is 840 m. Dead storage level (DSL) and Full reservoir level (FRL) of Ekburji reservoir are 143.26 m and 151.98 m respectively. The gross storage and dead storage capacity of reservoir as per project report are 14.12 Mm^3 and 2.15 Mm^3 respectively. First year of impounding of Ekburji reservoir is 1964.

III. AIM AND OBJECTIVES OF THE STUDY

The aim of study is to estimate the loss in capacity of Ekburji reservoir using remote sensing from impounding of reservoir.

Objectives of study are:

- To calculate water spread area of reservoir at regular interval from satellite imageries using ERDAS IMAGINE 9.3.
- To assess loss in capacity of reservoir from impounding using prismoidal formula.
- To update capacity curves of reservoir.
- To know annual sediment yield rate.

IV. DATA USED

NRSC Hyderabad website was browsed for the period between Year 2016 and 2017and a list of cloud free dates of Resource-sat 2 and IRS P6 (with LISS III and LISS IV sensor) satellite pass over Ekburji reservoir was prepared. Index map of Ekburji reservoir, salient features, area-capacity table during impounding of reservoir along with water levels of the dates of cloudfree imageries are procured from Ekburji Project, Irrigation Department, District-Washim.

The satellite data used in the analysis is given in the Table 1.

Table-1: Satellite data used for estimation of water spread area

Sr No	Sensor	Path/row/subscene	Date of pass	Elevation (m)	Designed Live Capacity (Mm^3)
1	LISS III	98/58	24-05-2016	143.30	0.04
2	LISS IV	98/58/C	06-02-2016	145.90	2.65
3	LISS IV	98/58/C	24-02-2017	147.80	4.50
4	LISS IV	98/58/C	07-01-2017	149.60	7.36
5	LISS III	98/58	27-10-2016	151.90	11.87
Capacity Covered					11.83
% Coverage of Live Capacity					98.83%


Date: 27-10-2016 (RL 151.90 m)


Date: 07-01-2017 (RL 149.60 m)


Date: 24-02-2017 (RL 147.80m)


Date: 06-02-2016 (RL 145.90 m)


Date: 24-05-2016 (RL 143.30 m)

Fig-2: FCC's of satellite images of different levels

V. METHODOLOGY

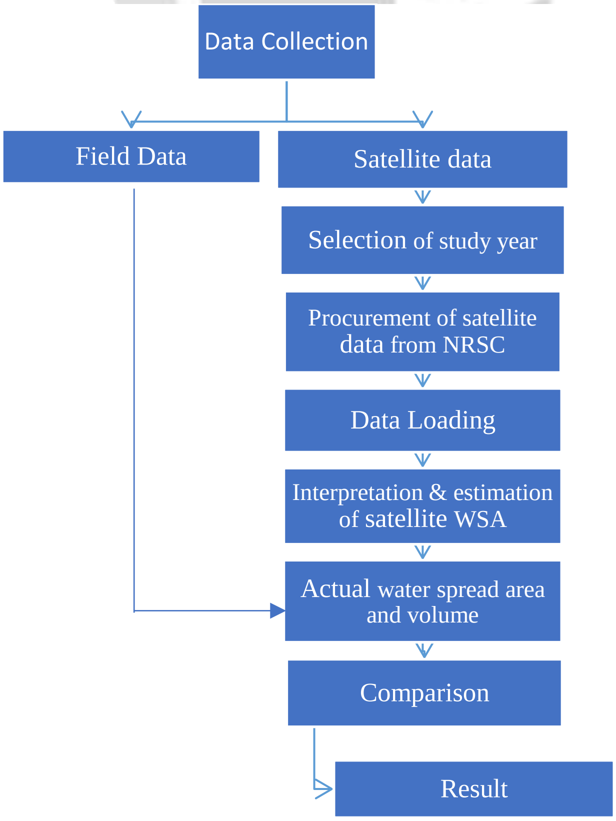

Fig-3: Flow chart of Methodology

Water spread area from satellite imageries is extracted by image processing using Erdas Imagine 9.3. On visual analysis, the pixels representing water spread area except at periphery are quite distinct and clear in FCC images. The reservoir area and its surrounding (area of interest) are separated from full imageries.

Further, classification of pixels is done. Classification is the process of sorting pixels into a finite number of individual classes, or categories, of data based on their data file values. If a pixel satisfies a certain set of criteria, then the pixel is assigned to the class that corresponds to that criteria. There are two ways to classify pixels into different categories:

1. Supervised Classification
2. Unsupervised Classification

In present study, unsupervised classification process is performed. Erdas Imagine uses the ISODATA algorithm to perform unsupervised classification. The ISODATA clustering method uses the minimum spectral distance formula to form clusters. It begins with either arbitrary cluster means or means of an existing signature set, and each time the clustering repeats, the means of these clusters are shifted.

The new cluster are used for the next iteration. The ISODATA utility repeats the clustering of the image until either a maximum number of iterations has been performed, or a maximum percentage of unchanged pixels has been reached between two iterations.

Once water spread area is calculated, computation of reservoir capacity at different levels is done using prismoidal formula.

Volume, $V = \frac{H}{3}\left(A_1 + A_2 + \sqrt{A_1 \times A_2}\right)$

Where, V = Reservoir capacity between two successive elevations h_1 and h_2

H = Elevation difference ($h_2 - h_1$)

A_1 and A_2 are areas of reservoir water spread at elevation h_1 and h_2.

VI. RESULTS AND ANALYSIS

As discussed earlier, satellite imageries were used to calculate water spread area. Water spread area at known elevation is calculated using image processing and is as shown in table 2.

Table-2: Water spread area estimated from satellite data

Sr No	Date of Pass	Elevation (m)	Area (Mm^2)
1	24-05-2016	143.30	0.256
2	06-02-2016	145.90	0.794
3	24-02-2017	147.80	1.150
4	07-01-2017	149.60	1.476
5	27-10-2016	151.90	1.860

Water spread area and incremental capacity at regular interval is calculated using prismoidal formula. As whole live storage is not able to cover with available set of imageries, capacity is extrapolated from MDDL to FRL. Water spread area and capacity calculated is as shown in table 3.

Table-3: Water spread area and Capacity of Ekburji reservoir at regular interval

Water Elevation (m)	**Water Spread area (1964) (Mm^2)**	**Water spread area (SRS survey) (Mm^2)**	**Live storage original survey (1964) (Mm^3)**	**Live capacity as per study area covered by images (2016) (Mm^3)**	**Live storage capacity extrapolated from MDDL to FRL**
MDDL143.26	0.649	0.248	0.000	-	0.000
143.3	0.655	0.257	0.040	0.000	0.012
144	0.751	0.405	0.580	0.231	0.243
145	0.892	0.611	1.420	0.739	0.751
146	1.046	0.810	2.790	1.449	1.461
147	1.238	1.004	3.820	2.357	2.369
148	1.442	1.191	4.770	3.455	2.467
149	1.630	1.372	6.340	4.737	4.749
150	1.814	1.547	8.110	6.197	6.209
151	2.000	1.716	9.910	7.829	7.841
151.9	2.204	1.862	11.870	9.440	9.452
FRL 151.98	2.222	1.875	11.970	-	9.601

The cumulative capacities of Ekburji reservoir computed at different elevations were plotted against corresponding elevation in order to generate elevation – capacity curve for both surveys, is shown in the graph as figure 4

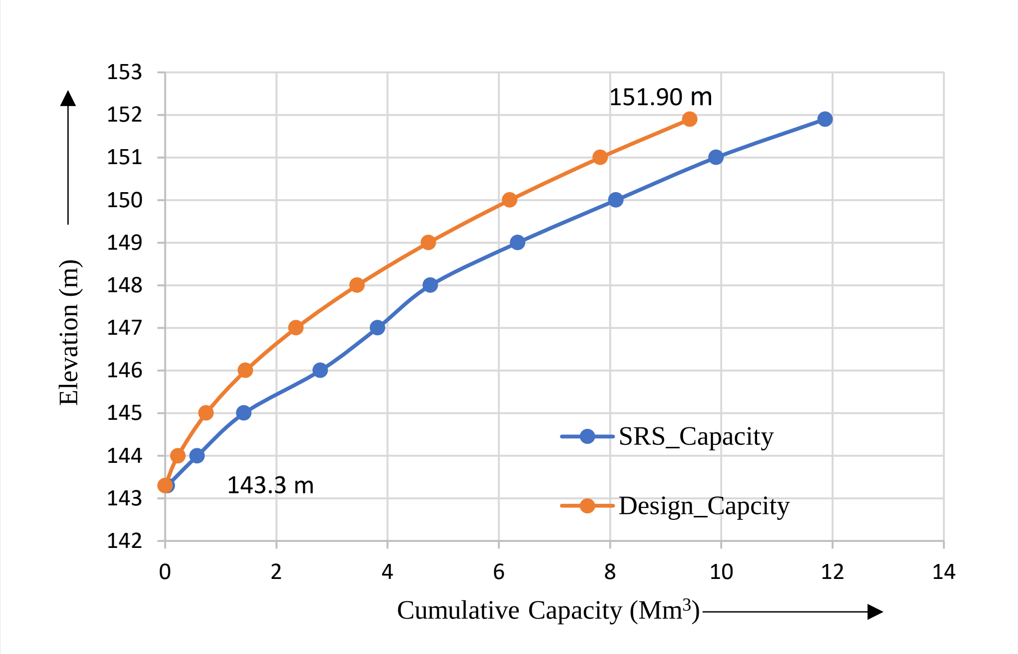

Fig-4: Comparison of original (1964) and revised (2016) cumulative capacity survey of Ekburji reservoir

VII. CONCLUSION

I. Remote sensing method of capacity assessment is relatively quicker and reliable method as compared to conventional methods subjected to availability of cloudfree satellite data and accurate field data.

II. The gross storage and live storage capacity of Ekburji reservoir for the year 1964 were 14.12 Mm^3 and 11.97 Mm^3 respectively. As per the studies with SRS data, these storages are estimated as 11.751 Mm^3 and 9.601 Mm^3 respectively.

III. Total percentage loss in whole live storage capacity (RL 143.26 m to RL 151.98 m) after extrapolation is found out to be 19.79%.

IV. Annual sediment yield rate of Ekburji reservoir as per current SRS survey is 0.6 mm/year.

V. Satellite Remote Sensing survey accounts for loss in capacity of reservoir in live storage only. It does not consider loss of capacity in dead storage. So, for this purpose conventional hydrographic survey is required to consider dead storage.

VI. Entire live storage is not covered as images were available between RL 143.30 m to RL 151.90 m and requires forward and backword extrapolation to cover whole live storage.

VII. REFERENCES

- CWC (2015), Compendium of silting of reservoir in India, Technical report on silting of reservoir in India, WS& RS directorate, Central Water Commission, New Delhi.
- Central Water Commission, Technical reports on reservoir capacity estimation using satellite remote sensing for different reservoirs. RS Directorate, New Delhi.
- Dilip G. Durbude And B. K. Purandara, (2005), Assessment of sedimentation in the Linganmakki reservoir using remote sensing, Journal of the Indian Society of Remote Sensing, Vol. 33, No. 4.
- D. S. Rathore, Anju Choudhary and R. K. Agarwal, (2006), Assessment of sedimentation in Hirakud reservoir using digital remote sensing technique, Journal of the Indian Society of Remote Sensing, vol. 34, no. 4.
- Pankaj Mani And Biswajit Chakravorty, (2007), Remote sensing-based sedimentation study of Maithon reservoir, Journal of The Indian Society of Remote Sensing, vol. 35, no. 1.

- S. R. Mandwar, Dr. H.V. Hajare and Dr. A. R. Gajbhiye, (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), ISSN: 2278-1684 Volume 4, Issue 6, PP 22-25.
- T. Thomas, R. K. Jaiswal, R. V. Galkate, S. Singh, (2009), Estimation of revised capacity in Shetrunji reservoir using remote sensing and GIS, Journal of Indian Water Resource Society, volume 29, No. 3.
- U. C. Roman, Suneeta Jatwa, M. N. Singh, S. Selvan, (2010), Reservoir Capacity loss estimation using satellite data, Indian Geotechnical Conference, IGS Mumbai chapter, pg-1083-1086.
- U.C Roman, S Sreekanth and Kamuju Narasayya, (2012), Assessment of Reservoir Sedimentation in Aid of Satellite Imageries – A case study", International eJournal of Mathematics and Engineering 192 (2012) 1839 – 1850.