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Assessment of Reservoir Storage Capacity by Satellite Remote Sensing Technique : A Case Study of Bhandardara reservoir, Dist.Ahmadnagar, Maharashtra, India

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ABSTRACT

Irrigation projects are constructed with the prime intention to provide irrigation facility to land for increasing food production. Water storage is also used to generate pollution free electricity as well as domestic purpose. Silt in the catchment area flows along with rain water stores in reservoir which causes siltation of reservoir. Deforestation, regular developmental activities like construction of roads and embankments, buildings, emergence of quarries and mining areas in the catchment of these reservoirs have caused excessive soil erosion which leads to heavy sedimentation in reservoirs. The eroded material transported in to reservoirs is deposited at different levels progressively reducing their storage capacity throughout their full range of water column. Studies show that sedimentation not only occurs in dead storage but also encroaches into live storage causing reduction in useful storage.

Bhandardara reservoir constructed across river Pravara in the Godavari river basin has been surveyed for capacity assessment by remote sensing technique in the year 2015. The reservoir is first impounded in the year 1926. The survey is useful for the field authorities in effective planning of available storage. Content table at 0.20 m interval was prepared for the live storage of the reservoir for the utility of the reservoir operating staff.

Keywords : IRS-P6, LISS-III, LISS-IV, Resourcesat-II, Sedimentation, Satelite Remote Sensing

I.INTRODUCTION

One of the essential inputs required for effective water planning of reservoir is assessment of its present storage capacity. Demand for Irrigation and non irrigation uses increasing fastly. It is therefore essential for the irrigation manager to know the quantum of water available in the live storage zone. The storage capacity of reservoirs gradually reduces due to silting. The eroded material transported in to reservoirs is deposited at

different levels progressively reducing their storage capacity throughout their full range of water column. SRS, DGPS bathymetric and DGPS survey methods can be opted for sedimentation assessment reservoir regarding the situations. Satellite Remote Sensing technique is cost effective, quick and reliable method. Resource Engineering Center, Nashik (M.S.) working under control of Water Resources Department, Govt. Of Maharashtra has done substantial work in the field of reservoir capacity assessment. Present survey of Bhandardara reservoir by satellite remote sensing technique has been conducted after 90 years (1926-2015) of its first impounding.

Remote sensing technique for reservoir sedimentation surveys is based on mapping of water-spread areas at the time of satellite over pass. It uses the fact that water-spread area of the reservoir reduces with the sedimentation at different levels. The parameters namely water-spread area and the elevation information are used to calculate the volume of water stored between different levels. These capacity values are then compared with the previously calculated capacity values to find out change in capacity between different levels.

II.STUDY AREA

The Bhandardara reservoir lies between Latitude 19^0: 29': 38" N to 19^0: 34': 00" N and Longitude 73^0: 40': 23" E to 73^0: 45': 58" E. The location of reservoir is shown in Fig.1 as Index Map. The reservoir was constructed on Pravara river, in Akole taluka of Ahmadnagar district. Pravara river is a tributary of Godavari river. Total catchment area of the reservoir is 121.73 sqkm. The designed gross storage capacity of the reservoir at FRL 744.725 m is 312.595 Mm^3 and live storage capacity between FRL & MDDL is 304.100 Mm^3. The MDDL of the reservoir is 698.07 m. The designed dead storage capacity is 8.495 Mm^3. The reservoir was first impounded in the year 1926.

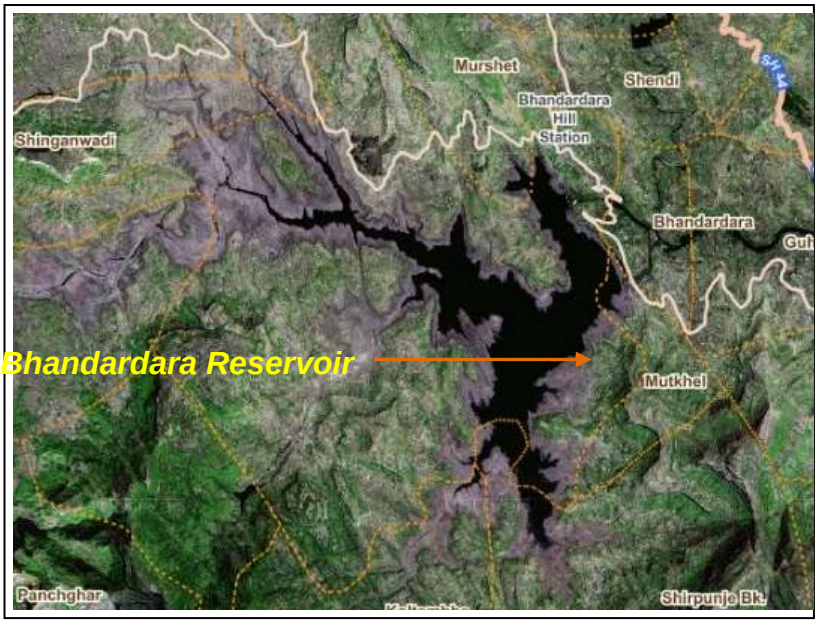

Fig.1 Location map of Bhandardara project

III.DATA USED

Mainly two Different types of data were used for study.

3.1 FIELD DATA

Following field data was obtained from the reservoir authority.

i) Latitude/Longitude i.e. geographical location of the reservoir
ii) Reservoir Levels for given dates of pass of the satellite
iii) Reservoir FRL and MDDL and submergence area
iv) First year of reservoir impounding.
v) Elevation-Area-Capacity table/curve.

3.2 SATELLITE DATA

IRS- P6 RESOURCESAT-1 and RESOURCESAT-2 LISS III data with a resolution of 24 m and RESOURCESAT-2 LISS-IV data with a resolution of 5 m was analyzed for this study. These satellite images of different water levels between R.L. 713.48 m and R.L 744.70 m of the period between Dec 2014 and Nov 2016 have been analyzed. The present study has covered 89.92 % of live storage zone (From MDDL 698.07 m to FRL 744.725 m). The satellite path is 95 and row is 59. Fig.2 shows FCC's of studied satellite images for Upper and lower water level.

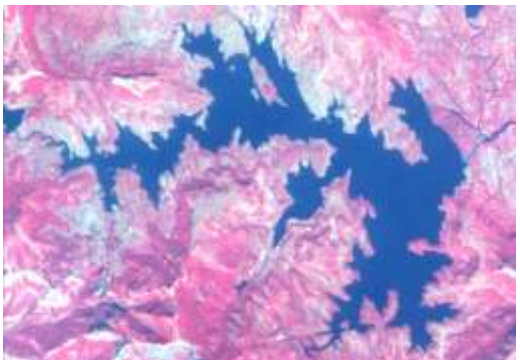

Fig.2.a) Date : 05-11-2016 (RL 744.70 m)

Fig.2.b) Date : 27-05-2015 (RL 713.48 m)

IV.METHODOLOGY

For Indian Remote Sensing Satellite data NRSC website was browsed and a list of cloud free dates of Resource-sat 2 and IRS P6 (with LISS III and LISS IV sensor) satellite pass over Bhandardara reservoir was prepared for the period between Year 2014-15 and 2015-16. The reservoir levels and corresponding water spread areas for dates of satellite pass were obtained from the field office. The selection of the satellite images was done after studying the draw down pattern of the lake levels, selected satellite data in Geo-referenced mode was procured from the NRSC Hyderabad.

Procedure followed as per following steps -

i) Digital data base creation

ii) Estimation of water-spread area

iii) Calculation of reservoir capacity

iv) Comparison of result with previous surveys

v) Estimation of live capacity loss due to sedimentation

Fig. 3 shows flow chart describes the methodology in brief.

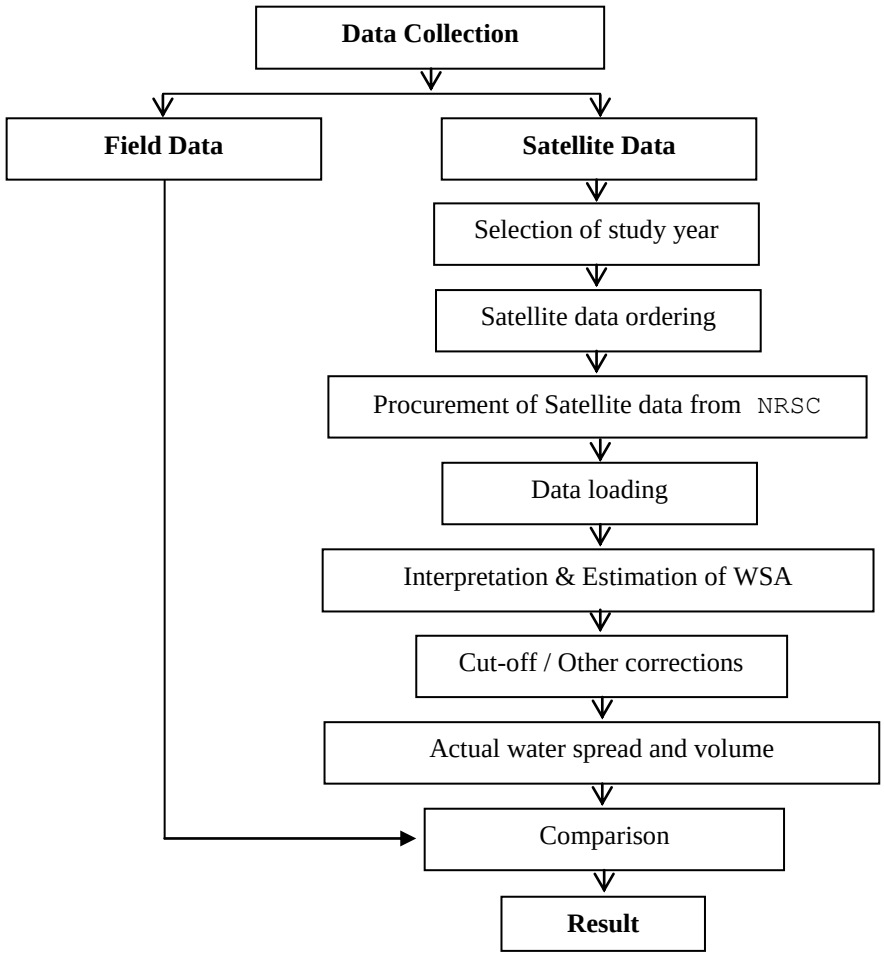

Fig. 3 : Procedural Flow Chart

V.WATER SPREAD AREA EXTRACTION

For area extraction unsupervised classification method is used. The ERDAS imagine analysis software is used for analysis. Unsupervised classification outputs were generated for specific scene and range of unsupervised classification for water body delineation was noted for respective scene. The Water Spread Areas (WSA) derived for all the scenes and their corresponding water levels are shown in Table 1.

Table 1 : Water spread areas estimated from satellite data

Sr. No.	Date of pass	Elevation in m.	Area in Mm^2
1	27-May-15	713.48	3.16
2	15-Apr-16	715.18	3.33
3	03-May-15	722.16	5.22
4	29-Dec-15	726.03	6.53
5	05-Dec-15	729.56	7.94
6	06-Mar-15	734.30	10.70
7	22-Jan-15	736.80	12.16
8	10-Dec-14	742.84	17.18
9	05-Nov-16	744.70	18.78

The water spread area on selected dates of satellite pass is shown in Fig.4.

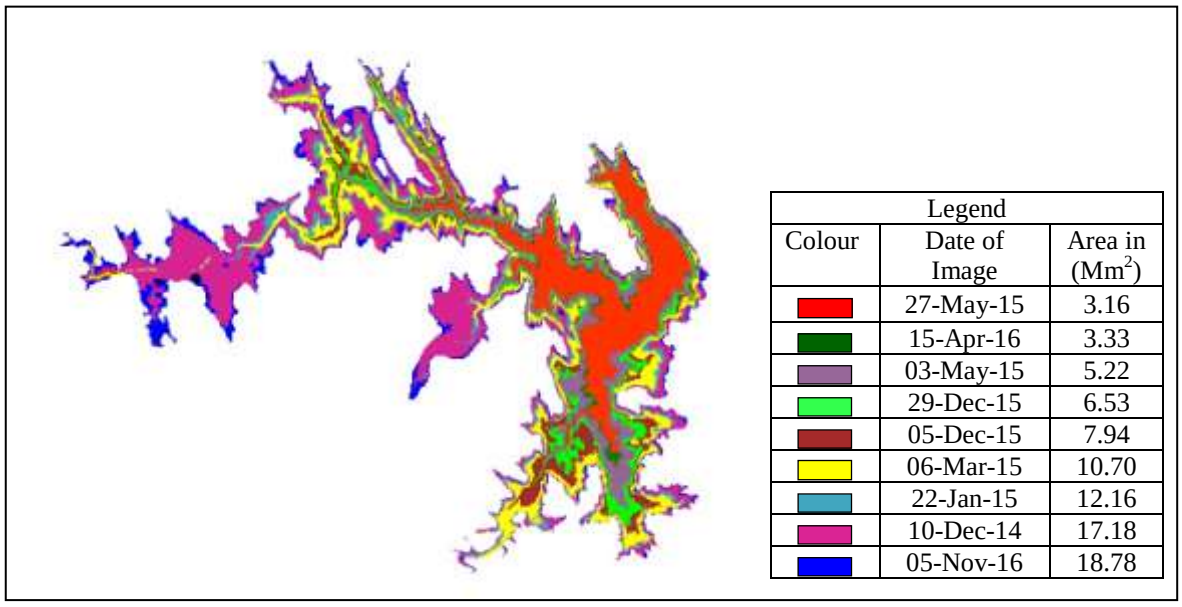

Fig. 4 : Water Spread Area for all satellite images

VI.WATER SPREAD AREA AT REGULAR INTERVAL

Water levels on the dates of pass for selected satellite data are not available at regular interval. To get WSA values at regular elevation interval, a curve was plotted between Elevation and the Revised Area. The best fit polynomial equation of second order was derived for the graph.

$$y = 0.0130\ x^2 + 0.0912\ x + 3.2144$$

R^2 = 0.9994 (R = Coefficient of co-relation)

Where x = Elevation difference in meters (measured above R.L. 713.48 m)

y = Water spread area in Mm^2

VII.CALCULATION OF RESERVOIR CAPACITY

Computation of reservoir capacity at different elevations has been done using following prismoidal formula.

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

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.

The comparison of water spread area as well as storage capacity obtained through remote sensing analysis with original WSA and capacity of reservoir in year 1926 is given in Table 2. It shows that live storage in studied zone i.e. from 713.48 m to 744.70 m having revised capacity 276.689 Mm^3 against design live storage 273.460 Mm^3.

Table 2 : Comparison of WSA and capacity of reservoir with available original data

Water elevation (m)	WSA (Mm^2)		Storage capacity (Mm^3)	
	Original 1926	SRS 2015	Original 1926	SRS 2015
RL 713.48	3.423	3.214	0.000	0.000
714.00	3.541	3.265	1.779	1.684
715.00	3.778	3.383	5.433	5.007
716.00	4.014	3.527	9.328	8.459
717.00	4.205	3.696	13.429	12.069
718.00	4.411	3.892	17.735	15.861
719.00	4.604	4.114	21.895	19.862
720.00	4.794	4.362	29.619	24.098
721.00	4.943	4.635	30.117	28.594
722.00	5.151	4.935	34.330	33.377
723.00	5.434	5.261	39.850	38.473
724.00	5.724	5.613	45.370	43.908
725.00	6.062	5.990	50.920	49.707
726.00	6.510	6.394	57.464	55.897

Water elevation (m)	WSA (Mm^2)		Storage capacity (Mm^3)	
	Original 1926	SRS 2015	Original 1926	SRS 2015
727.00	6.968	6.824	64.014	62.504
728.00	7.441	7.279	70.856	69.553
729.00	7.904	7.761	78.105	77.071
730.00	8.383	8.269	87.356	85.084
731.00	8.873	8.803	95.187	93.618
732.00	9.375	9.362	103.011	102.698
733.00	9.890	9.948	111.294	112.351
734.00	10.422	10.560	120.434	122.603
735.00	11.055	11.197	130.232	133.479
736.00	11.689	11.861	140.919	145.007
737.00	12.344	12.551	151.753	157.210
738.00	12.878	13.267	162.810	170.117
739.00	13.429	14.008	175.732	183.752
740.00	14.024	14.776	190.124	198.142
741.00	14.963	15.570	205.487	213.313
742.00	16.055	16.389	220.388	229.291
743.00	17.121	17.235	239.226	246.101
744.00	18.105	18.107	256.232	263.770
RL 744.70	18.833	18.733	273.460	276.663

VIII.RESULT AND DISCUSSIONS

Storage capacity of Bhandardara reservoir between RL 713.48 m and RL 744.70 m is estimated as 276.663 Mm^3 for the year 2015 against original storage capacity of 273.460 Mm^3 between these levels, which is more than the designed capacity. It is observed that designed capacity between RL 713.48 m to 733.00 m (a part of studied zone) is more than SRS capacity. Afterword from RL 733.00 m to RL 744.70 m, SRS capacity found more than designed capacity. Cumulative difference in capacity is 3.203 Mm^3 for studied portion.

For studied portion, it is observed that comparison of present capacity with original capacity of year 1926, there is a no loss in capacity. Present capacity (SRS 2015) of reservoir is found 1.171% more than designed capacity.

IX.CONCLUSION

Following conclusions can be drawn from the study:

(i) The live storage capacity of studied portion (RL 713.48 m to RL 744.70 m) of Bhandardara reservoir is 276.663 Mm^3 in year 2015.

(ii) In studied portion, capacity is 1.171 % more than designed capacity, after 90 years since first impounding in 1926, indicating no loss in capacity.

X.RECOMMENDATION

Periodical monitoring of siltation helps keeping the content table updated. Remote sensing technique is a cost effective technique for such surveys.

REFERENCES

[1] Technical report *"Capacity Assessment of Bhandarara reservoir, Dist.Ahmadnagar by Satellite Remote Sensing Technique"* for Resource Engineering Centre, Nashik.

[2] 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.

[3] Central Water Commission, Technical reports on reservoir capacity estimation using satellite remote sensing for different reservoirs. RS Directorate, New Delhi.