International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No. (01), January 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

Assessment of storage capacity of the Bhatsa Reservoir, Dist. Thane using SRS Technique

A. Y. Morkar[1], M.M. Kulkarni [2],R. S. Deshmukh[3]

[1,2,3]*Resource Engineering Centre, Nashik - 422004, Maharashtra, (India)*

ABSTRACT

Many lakes and reservoirs, which are important manmade fresh water resources, are under the threat of sedimentation. today which can have adverse impact on the storage potential and water quality. The eroded soil carried away by streams and nallas settles down in the lakes at different elevations within submergence area reducing storage potential at all elevations. For realistic and effective planning of available water storage, water manager must know the net storage available in the reservoir excluding the silt volume. To ascertain the net available storage, consistant periodic sedimentation surveys of lakes and reservoirs must be conducted.

The satellite remote sensing is very useful, economical and reliable tool for conducting such surveys and monitoring sedimentation in lakes / reservoirs. Resource Engineering Centre, at Nashik under the control of Maharashtra's Water Resources Department has been monitoring the lakes and reservoirs of major and medium size mainly in the context of sedimentation by adopting remote sensing technology. Remote Sensing technique gives us directly the waterspread area of the reservoir at a particular elevation on the date of pass of the satellite. This helps us to estimate sedimentation over a period of time. This paper describes assessment of sedimentation carried out for the Bhatsa Reservoir, Dist. Thane using Remote Sensing satellite imageries. The reservior was impounded in year 1979, present survey is carried out in year 2017.

The loss in reservoir live capacity due to sediment deposition for a period of 39 years since the impounding of the dam in 1979 to 2017 was determined to be 55.51 Mm^3 which translate to 9.54 % cumulative loss in live capacity in studied portion. The revised live capacity of the dam is estimated as 526.567Mm^3. The annual rate of sedimentation was calculated to be 0.24 % per annum. Bhatsa reservoir acts as water supply agency to Mumbai, economic capital of India. Hence water planning is very critical to cater the need of such big city. Periodic assessment survey of storage helps to cater the demand.

Key words:Images, IRS P6, Resourcesat2, Satellite Remote Sensing, Sediment

I.INTRODUCTION

One of the essential inputs required for effective water planning of reservoir is assessment of its present storage capacity. It is therefore essential for the irrigation manager to know the quantum of water available in the live storage zone. Remote sensing technique for reservoir sedimentation surveys is essentially 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.

The Resource Engineering Centre, the State's Water Resources Department, has done substantial work in the field of reservoir capacity assessment. Present survey of Bhatsa reservoir by satellite remote sensing technique has been conducted after 39 (1979-2017) years of its first impounding.

II. OBJECTIVES

The present capacity assessment study was conducted with the following objectives

- To estimate the present live storage capacity of reservoir
- To update Elevation-Capacity curve for the live storage zone of reservoir.

III. DETAILS OF RESERVOIR

The Bhatsa reservoir lies between Latitude 19^0: 29':41" N to 19^0: 36': 15" N and Longitude 73^0: 23': 19" E to 73^0: 32': 01"E. The location of reservoir is shown in Fig.1 as Index Map. The reservoir was constructed on confluence of river Bhatsa and Chorana, near village Sajiwali in Shahapurtaluka, Thane district. Total catchment area of the reservoir is 388.5sqkm. The designed gross storage capacity of the reservoir at FRL142.07m is 976.10$Mm^3$and live storage capacity between FRL and MDDL is 942.10 Mm^3. The MDDL of the reservoir is 79.20 m. The designed dead storage capacity is 34.0 Mm^3. The reservoir was first impounded in the year 1979.The salient features are given in Annexure I.

Fig.1 Index Map of Bhatsa Project

IV.DATA

4.1 Field Data

Following field data was obtained from the reservoir authority.

4.1.1 Latitude/Longitude i.e. geographical location of the reservoir

4.1.2 Reservoir Levels for given dates of pass of the satellite

4.1.3 Reservoir FRL and MDDL and submergence area

4.1.4 First year of reservoir impounding.

4.1.5 Elevation-Area-Capacity table/curve.

4.2 Satellite Data

Resource-sat 2 and IRS P6 with sensor LISS III have a resolution of 24m and LISS IV with a resolution of 5.8 m images were analyzed for this study. These satellite images of different water levels between R.L. 114.14 m and R.L.141.74 m of the period between Oct 2013 and Feb 2017 have been analyzed.The present study has covered 61.79 % of live storage zone (From MDDL79.20 m to FRL 142.07m). Table 1 gives the dates of satellite passes with respective water levels and capacity. Fig.2 shows FCC's of all studied satellite images of different water levels.

Table 1: Details of satellite image pass and capacity coverage

Path / Row /Shift : 94 / 68 / 50% Live Storage:942.10 Mm^3

Sr. No.	Date of Pass	Elevation m	Live capacity coverage (Mcum)
1	27-May-14	114.14	386.388
2	10-Apr-16	117.26	435.729
3	04-Apr-15	119.29	469.861
4	05-Mar-16	121.56	509.919
5	16-Mar-14	125.55	585.650
6	17-Jan-16	127.06	616.063
7	04-Feb-17	130.44	688.053
8	29-Dec-14	132.86	742.645
9	18-Dec-16	135.88	814.643
10	10-Dec-13	137.27	849.116
11	23-Oct-13	141.74	968.116
Capacity Covered			582.079
% coverage of Live Capacity			61.79 %

V.METHODOLOGY

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 Bhatsa reservoir was prepared for the period between Year 2013 and 2017. 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.

Following flow chart (Fig.2) describes the methodology in brief.

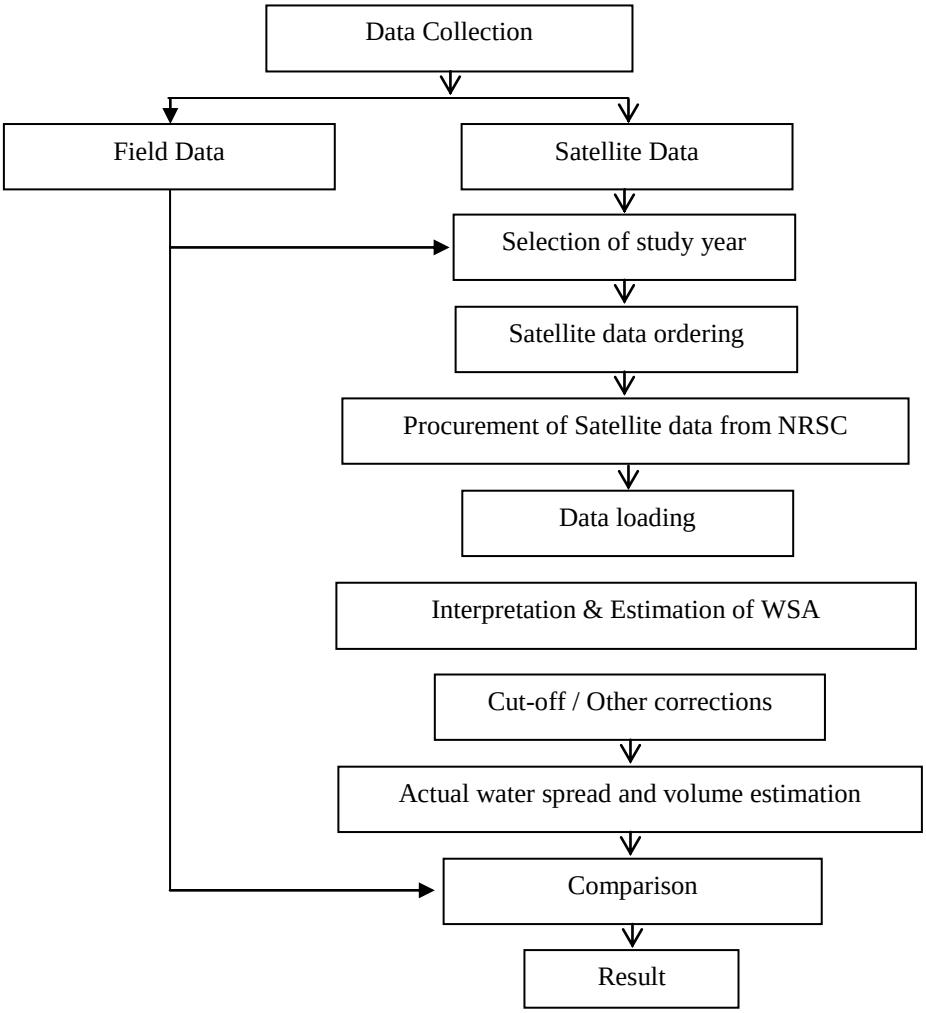


Fig.2 : Procedural Flow Chart

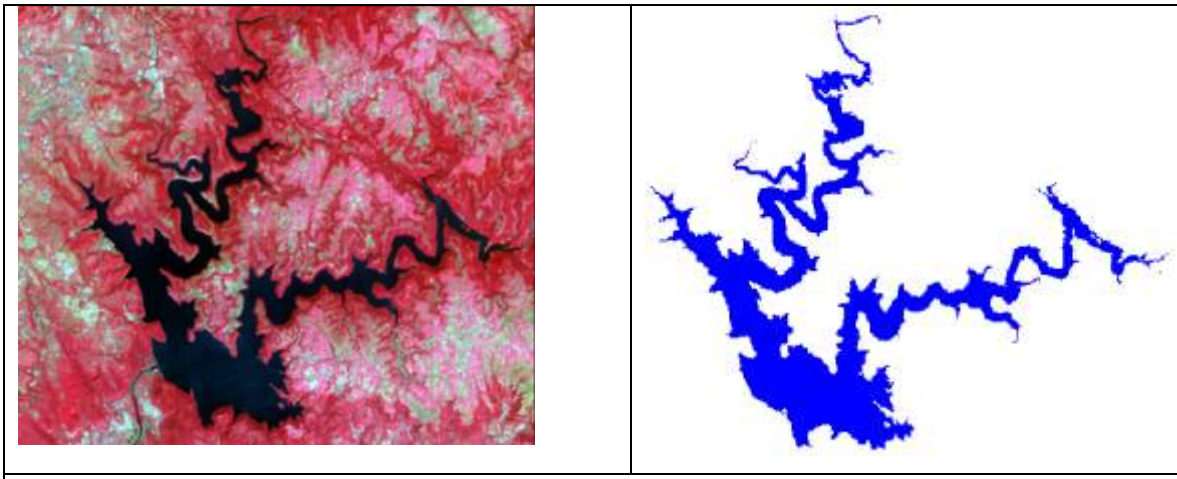
VI.WATER SPREAD AREA EXTRACTION

For Bhatsa reservoir, unsupervised classification outputs were generated for specific scene. The Water Spread Areas (WSA) derived for all the scenes and their corresponding water levels are shown in Table 2.

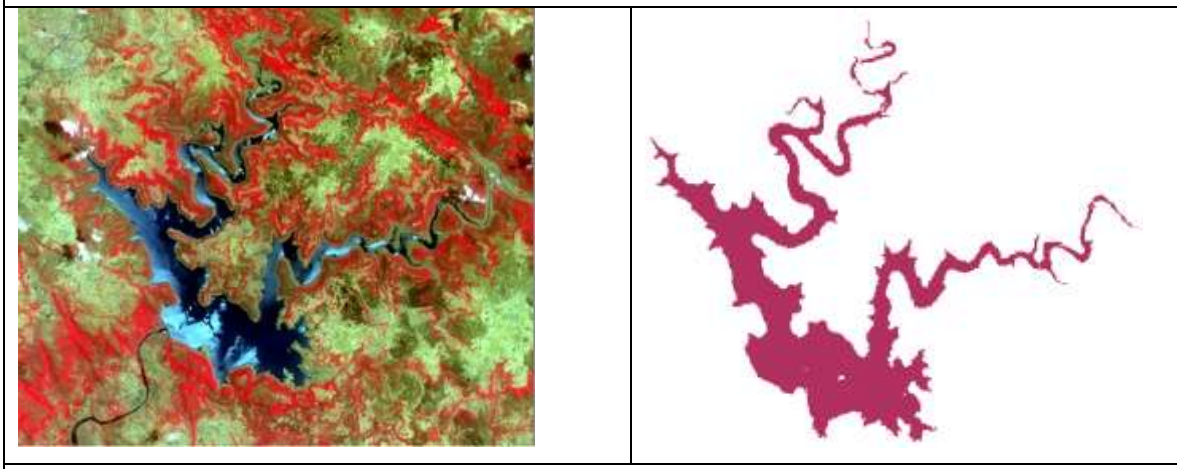
Table 2: Water spread areas estimated from satellite data

Sr.No.	Date of pass	Elevation in m.	Area in Mm^2
1	27-May-14	114.14	14.50
2	10-Apr-16	117.26	15.83
3	04-Apr-15	119.29	16.68
4	05-Mar-16	121.56	17.39

5	16-Mar-14	125.55	18.74
6	17-Jan-16	127.06	19.33
7	04-Feb-17	130.44	20.41
8	29-Dec-14	132.86	21.42
9	18-Dec-16	135.88	22.40
10	10-Dec-13	137.27	23.95
11	23-Oct-13	141.74	25.04



23 Oct 2013 (RL 141.74 m)



27 May 2014 (RL 114.14 m)

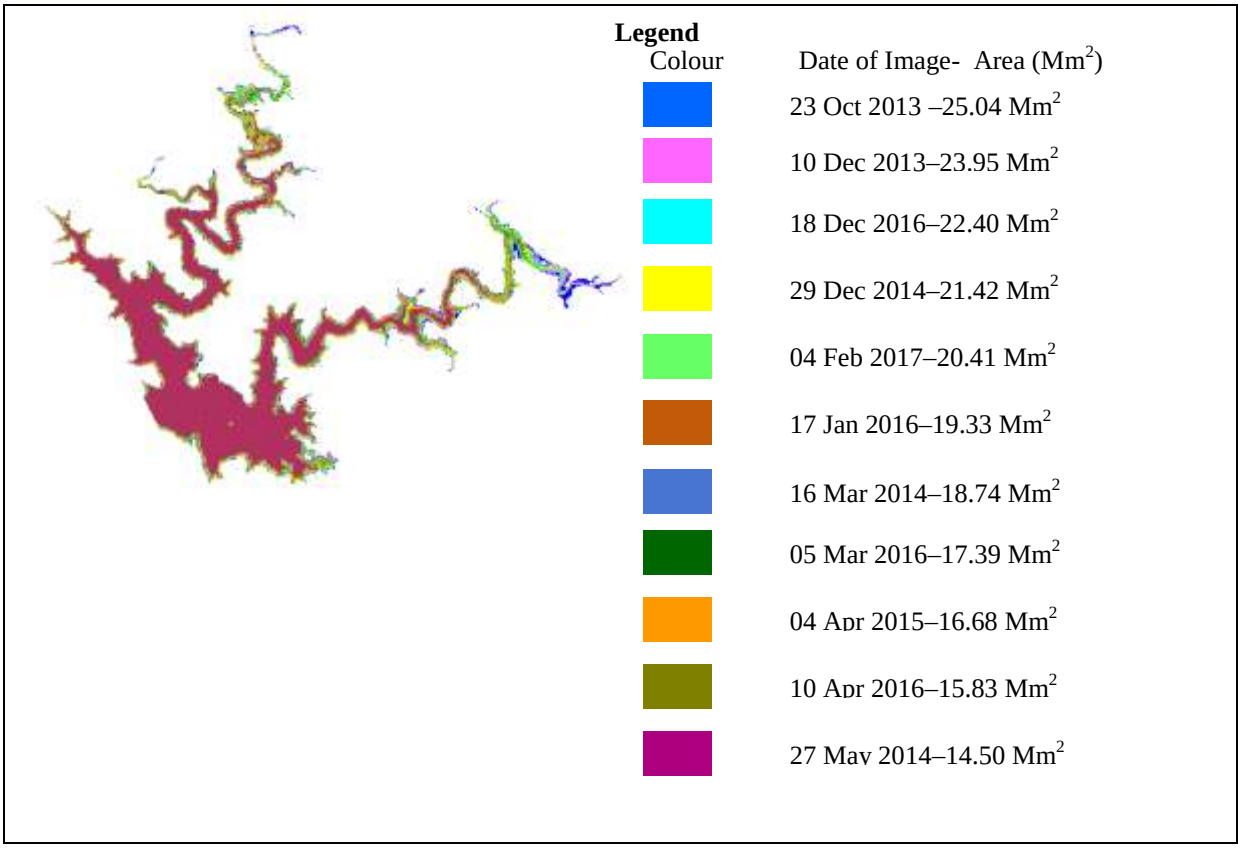


Fig. 3: Water Spread Areas at Different Elevations for Bhatsa Reservoir

VII.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 (Fig 6).

$y = 0.0013x^2 + 0.3428x + 14.6784$

$R^2 = 0.9940$ (R = Coefficient of co-relation)

Where x = Elevation difference in meters (measured above R.L. 114.14 m)

y = Water spread area in Mm^2

The water spread area obtained through remote sensing analysis is given in Table 3.

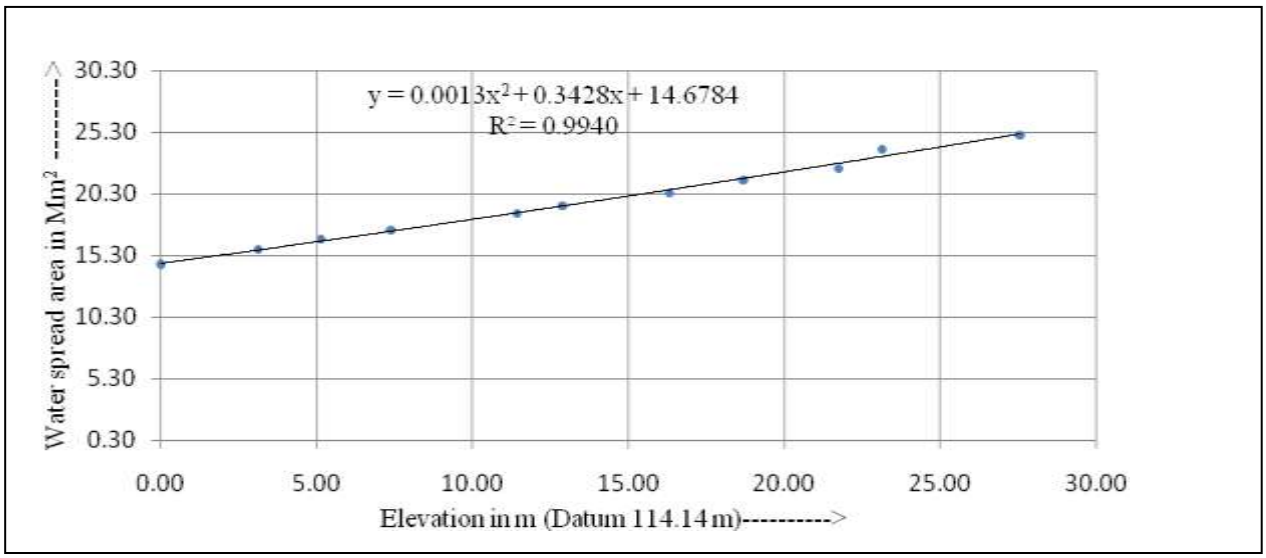


Fig. 4 : Elevation Vs Area Curve for BhatsaReservoir as per analysis

VIII.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 live storage capacity of reservoir of year 2017 with available satellite image data is given in Table 4. It shows that live storage in studied zone i.e. from 114.14 m to 141.74 m (Max RL) having revised capacity526.567Mm^3 against design live storage 582.079 Mm^3.

Table 4 : Comparison of live storage capacity of reservoir(Datum 114.14m)

Water elevation (m)	Live Storage Designe Survey 1979 (Mm^3)	Live capacity SRS Survey 2017 (Mm^3)
114.14	0.000	0.000
115	13.338	12.750
116	28.934	27.891

117	45.050	43.371
118	61.552	59.186
119	78.440	75.333
120	95.796	91.811
121	113.393	108.617
122	131.497	125.747
123	150.025	143.200
124	168.978	160.972
125	188.375	179.062
126	208.169	197.466
127	228.432	216.183
128	249.142	235.208
129	270.302	254.541
130	291.996	274.177
131	313.971	294.115
132	336.493	314.352
133	359.473	334.886
134	382.913	355.713
135	406.982	376.832
136	431.155	398.239
137	455.924	419.932
138	481.120	441.908
139	506.742	464.165
140	532.919	486.700
141	561.172	509.511
141.74	582.079	526.567

Water elevation (m)	Designe Survey 1979 (Mm^2)	SRS Survey 2017 (Mm^2)
114.14	15.30	14.68
115	15.94	14.97
116	15.92	15.31
117	16.31	15.65
118	16.70	15.98
119	17.08	16.31
120	17.47	16.64
121	17.89	16.97
122	18.32	17.29
123	18.74	17.61
124	19.17	17.93
125	19.59	18.25
126	20.04	18.56
127	20.49	18.87
128	20.94	19.18
129	21.38	19.49
130	21.83	19.79
131	22.29	20.09
132	22.75	20.39
133	23.21	20.68
134	23.67	20.97
135	24.13	21.26
136	24.56	21.55
137	24.98	21.84
138	25.41	22.12
139	25.84	22.40
140	26.26	22.67
141	26.69	22.95
141.74	27.00	23.15

The comparison of designed and Revised Area Vs Elevation curve for Bhatsa reservoir is shown in Fig.7. Fig.8 shows comparison of designed and revised storage capacity of Bhatsa reservoir for studied interval from RL 114.14 m to RL 141.74 m.

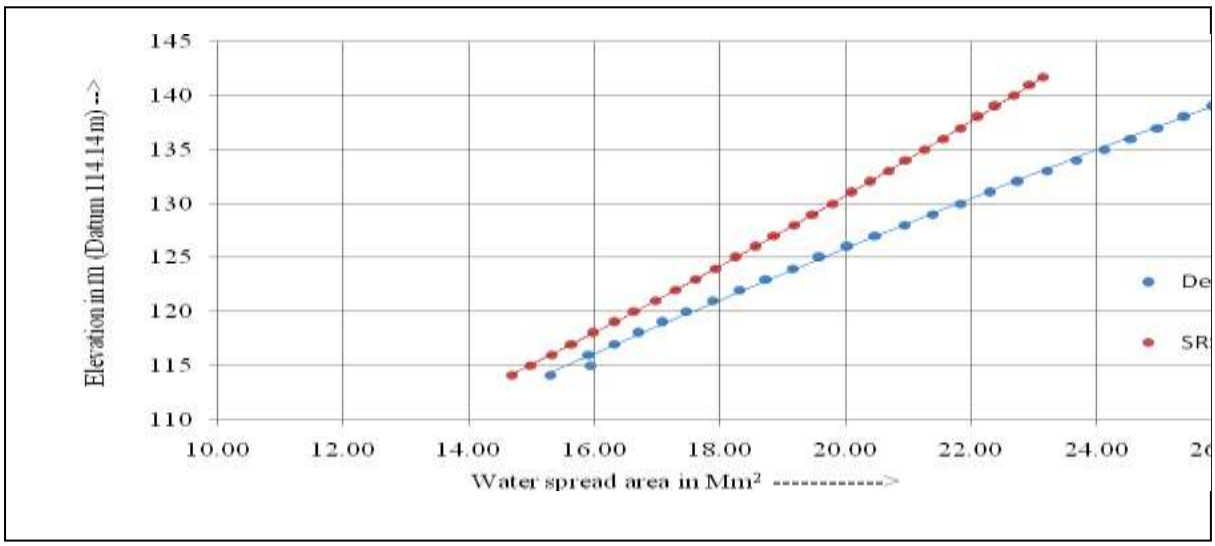


Fig. 5 : Elevation – Area Curve for different years for Bhatsa Reservoir (Datum RL 114.14 m)

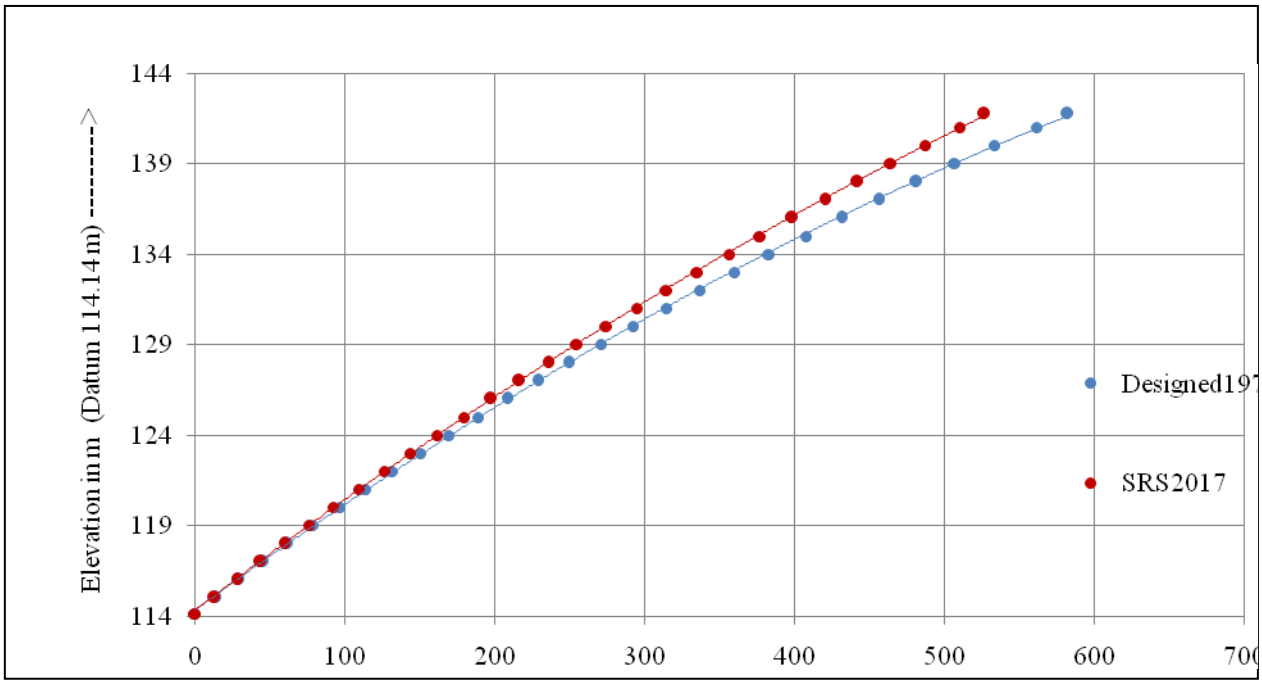


Fig. 6 : Elevation – Capacity Curve for different years for Bhatsa Reservoir (Datum RL 114.14 m)

IX.FIELD VISIT AND GROUND TRUTH COLLECTION

A field visit was conducted by the team of this office for ground truth data collection on Date 6 June 2017. For verification of ground truth, doubtful/ mixed signature locations along the periphery of the reservoir were marked on satellite images as well as on classified image printouts. Field visit helps in identification of correct class between vegetation and water at such locations. GPS readings were taken with the help of Trimble Juno Handheld GPS device and simultaneously latitude /longitude values of reservoir components have been recorded during the visit.

X. RESULT AND DISCUSSIONS

Storage capacity of Bhatsa reservoir between RL 114.14 m and RL 141.74 m is estimated as 526.567Mm^3 for the year 2017 against designed storage capacity of 582.079Mm^3 between these levels. Table 5 shows the live capacity loss due to sedimentation between different years.

Table 5 : Live capacity loss due to sedimentation (Studied area)

Details	Designe Survey 1979	SRS Survey 2017
Storage capacity between (RL114.14m to RL141.74m) in Mm^3	582.079	526.567
Capacity lost between two consecutive surveys Mm^3	-	55.51
Cumulative % Loss	-	9.54 %
Period in years since 1st impoundment year 1979		39
Annual % Loss		0.24 %
Silt Rate (Ha-m/100 km^2 /year)		36.64
Silt Rate (mm/year)		3.664

XI. LIMITATIONS

11.1For factual results, latest 3 years images should be used. When the water levels of 4 years (2013-2017) were observed, the lowest water level available was RL 114.14 m and highest water level available was RL 141.74 m. Since the MDDL of the reservoir is 79.20m, the storage from MDDL to RL 114.14m was not considered for factual result. Hence live storage portion between RL 114.14 m to RL 141.74m was taken for study.

11.2 The cloud free satellite data throughout reservoir operation in single year may not be available. Hence such data from different years are selected.

11.3 General error can creep in the identification of tail end of reservoir, in marginal periphery.

XII.CONCLUSION

Following conclusions can be drawn from the study:

12.1 The live storage capacity of Bhatsa reservoir is 526.567 Mm^3 in year 2017.

12.2 Capacity loss of 9.54 % in live storage is observed in a period of 39 years since first impounding in 1979 for the 61.79 % of live storage capacity studied.

12.3 Siltation rate of Bhatsa reservoir is 3.664 mm/year.

REFERENCES

[1.] Technical report of capacity estimation using satellite remote sensing for Bhatsa reservoir, 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.

[4.] Research paper-Assessment of Reservoir Sedimentation Using Remote Sensing Satellite Imageries, byKamujuNarasayya, U C Roman, S. Sreekanth and SunnetaJatwa, Central Water and Power Research Station, P.O. Khadakwasla, Pune – 411024, INDIA

[5.] IJIRST –International Journal for Innovative Research in Science & Technology| Volume 1 | Issue 12 | May 2015, by Miss. Mili V. Bhavsar&Prof. K. B. Gohil, Department of Water Resources Management, Shantilal Shah Engg. College, Bhavnagar