

# ASSESSMENT OF SEDIMENTATION IN KRISHANARAJA SAGAR RESERVOIR OF KARNATAKA, INDIA USING REMOTE SENSING TECHNIQUE

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**Abstract** - Reservoirs are the life line components for the overall development of a country are facing the problem of sedimentation. The reservoirs are fast losing the storage capacity due to higher rate of siltation than their designed value. Sustainable reservoir water management demands for proper and periodic assessment of its capacity. Remote sensing technology being superior compare to conventional method gives directly the water-spread area of the reservoir at a particular elevation on the date of pass of the satellite. Remote sensing technique with ERDAS software, the change in water-spread area can be analyzed to evaluate the sediment deposition in a reservoir. This paper describes assessment of storage capacity and sedimentation of Krishna Raja Sagar (KRS) reservoir using remote sensing technique. The capacity of reservoir was 1136.394 Million Cubic Meter ( $Mm^3$ ) at 121.18 ft and the loss in the capacity between 1932 and 2014-15 was 143.055 Million Cubic Meter ( $Mm^3$ ) due to sedimentation at an average rate of 1.744  $Mm^3$  per year.

**Key Words:** Reservoirs, Sedimentation, Water-spread area, Remote Sensing, ERDAS, etc

## 1. INTRODUCTION

Reservoirs are the life line components for the overall development of the country that are facing the problem of sedimentation. In the recent decades there has been an increasing concern over the storage capacity of reservoirs due to the scarcity of water particularly in a developing country like India. Sedimentation is the crucial problem faced by every reservoir. The silt deposited at different levels reduces the storage capacity of the reservoir and the useful life of the reservoir (Smith and Pavelsky 2009, Sreenivasulu and Udayabaskar 2010). Reduction in the storage capacity beyond a point, will hinders the functionality of the reservoirs for which it was designed. An estimated 1% reduction in the total capacity of world's reservoir due to sedimentation was observed every year (Chandran R et al. 2006, White R 2001 and Mahmood K 1887). The study of 43 reservoirs in India indicated that the sedimentation rate varies between 30 and 2785  $m^3/km^2/year$  (Shangle, 1991).

Presently, in India many reservoirs are facing the problem of sedimentation resulting in reduction of capacity of about 0.5 % to 1.50 % annually. Efficient reservoir water management

calls for periodic assessment of its capacity. Periodic evaluation of the sediment deposition and storage capacity of reservoirs is an important aspect of water resources management. Conventional techniques of quantification of reservoir sedimentation are cumbersome, costly, time consuming and involves huge man power.

With the advent of Satellite Remote Sensing (SRS) techniques, it has become convenient and far less expensive to quantify the sedimentation in a reservoir. Remote sensing technique being a fast, accurate and advanced technology provides economical and time effective method for estimation of sedimentation rate and storage capacity of a reservoir (Sebastin 1995, Jain 2002). Various studies by Manavalan (1990), Jeyaseelan and Thiruvengadachari (1997), Chandrasekar and Jeyaseelan (2000), Jeyakanthan (2002), Goel (2002), Jain (2002) Peng (2006), has revealed that remote sensing technique provides the rapid, economical, accurate estimation of capacity of a reservoirs and sedimentation rate. SRS techniques 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 area of reservoir at different levels between full reservoir level (FRL) and maximum draw down level (MDDL) in different months of the year are computed from satellite imageries. Knowing the reservoir levels on date of pass of the satellite, existing capacity will be obtained using prismoidal formula and compared with the original capacity that at the time of impoundment of reservoir to assess the extent of loss of reservoir capacity. Present study is carried out using SRS technique for KRS reservoir located at Mandya district of Karnataka state and ERDAS Imagine software was used for extraction of water spread area from satellite imageries.

## 2. STUDY AREA

Kirshna Raja Sagara, (KRS) one of the famous dams of South India named after Kirshna Raja Wodeyar IV of Mysore. It is a gravity dam made of surki mortar situated on Kaveri River near kannambadi village of Mandya district in state Karnataka constructed between the years 1911-1931. The dam also boasts of being the first irrigation dam of India. The dam lies between 12°25'0" N latitude and 76°33'0" E

longitude with a catchment area of 10619 Km<sup>2</sup>. The dam has a height of 39.62 m above RBL with full reservoir level (FRL) of 124.8ft. The length of dam is 2620m. The gross capacity at FRL is 1408Mm<sup>3</sup> with a live storage 1172 Mm<sup>3</sup> having a water spread area at FRL 130 Km<sup>2</sup>. The Fig. 1 shows the Location map of study area.

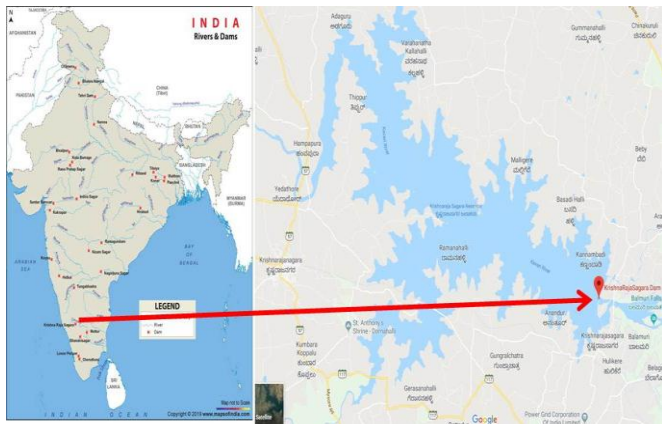


Fig -1: Location Map of the Study Area (KRS Dam)

### 3. METHODOLOGY AND DATA USED

In the present study Multi-date satellite data of LANDSAT-8 OLI (resolution 30m) passing over KRS reservoir for the six clouds free dates between November 2014 to May 2015 were downloaded from USGS Earth Explorer. The path and row of the downloaded imageries of the study area were 144 and 51 respectively. The satellite data for different dates were processed in ERDAS Imagine 2014 software to delineate the water-spread area of the KRS reservoir.

The Normalized Difference Water Index (NDWI) for all imageries varies from -1 to 1. NDWI were used to extract water pixels from the rest. The extracted water body of KRS dam as on 21-05-2015 is as shown in Fig 2.

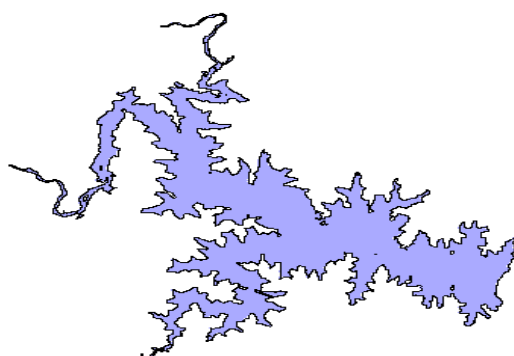


Fig -2: Water Spread Area of the KRS Dam from LANDSAT-8

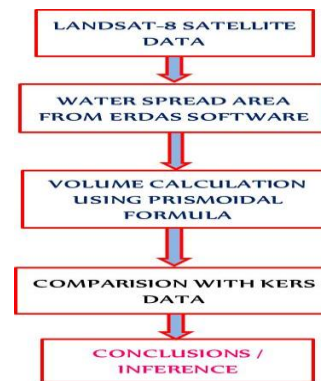


Fig -3: Work flow process

The reservoir elevations of the downloaded images are obtained from Karnataka State Natural Disaster Monitoring System (KSNDMC) for the estimation of capacity of KRS. The satellite data used in the analysis presented in the Table1.

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

Sl. No	Satellite	No of Water Pixels	Date of Pass	Elevation in ft	Water-spread Area in Km <sup>2</sup>
1	LANDSAT-8 OLI	128513	21-05-15	121.18	115.662
2	LANDSAT-8 OLI	116813	03-04-15	117.34	105.132
3	LANDSAT-8 OLI	101989	18-03-15	111.82	91.79
4	LANDSAT-8 OLI	84585	14-02-15	103.00	76.12
5	LANDSAT-8 OLI	66896	13-01-15	96.29	60.206
6	LANDSAT-8 OLI	47335	10-11-14	82.00	42.60

The revised areas brought in from this operation were used to compute the revised volume between two consecutive elevations by using prismatic formula.

$$V = \frac{H}{3} \times [A_1 + A_n + 4(A_2 + A_4 + A_{n-1}) + 2(A_3 + A_5 + \dots + A_{n-2})]$$

Where,

V = volume between two consecutive elevations,

A<sub>1</sub>, A<sub>2</sub> = contour areas

H = difference between elevations 1 and 2

The original Elevation-capacity table before the impoundment of the dam (1932) was obtained from Karnataka Engineering Research Station (KERS). The revised

volume was compared with the original volume in each zone and the difference between the two gave the capacity loss due to sedimentation.

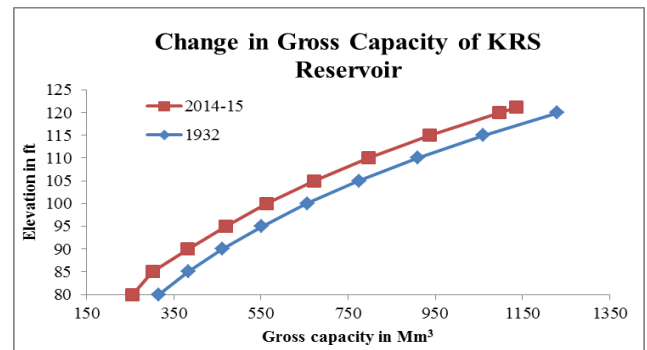
### 3. RESULTS AND DISCUSSIONS

The satellites data of six different dates have been analyzed to obtain the revised water spread areas of KRS reservoir. The water spread area, volume for the year 2014 -15 were calculated. The gross capacity of KRS reservoir at 121.18 ft was 1136.394 Mm<sup>3</sup> as against its original capacity of 1279.449 Mm<sup>3</sup>. The results have been presented in Table 2. Since the satellite imagery at the dead storage level of 60ft was not available for 2014-15 the water spread area and gross capacity of the reservoir at 60 ft was estimated with the previous Integrated Bathymetric Survey conducted by KERS in 2009.

**Table -2:** Gross capacity of KRS Reservoir in 2014-2015

Date	Elevation in ft	Depth in m	Area in Km <sup>2</sup>	Vol. in Mm <sup>3</sup>	Cumulative Capacity Volume in Mm <sup>3</sup>
-----	60.00	---	16.46	-----	89.19
21-05-15	82.00	6.70	42.60	191.27	280.46
03-04-15	96.29	4.35	60.20	222.84	503.31
18-03-15	103.00	2.04	76.12	139.12	642.44
14-02-15	111.82	2.68	91.79	225.42	867.86
13-01-15	117.34	1.68	105.13	165.57	1033.44
10-11-14	121.18	1.17	115.66	129.19	1136.39

The revised water spread area was compared with water spread area during impoundment of reservoir in 1932. From the study, it can be inferred that 143.055 Mm<sup>3</sup> of the capacity had been lost to sedimentation under study in a period of eighty six years (1932 - 2014). Further, the rate of sedimentation since the impoundment of reservoir works to be 1.744 Mm<sup>3</sup> per year. The change in gross capacity of KRS reservoir from 1932 to 2014-2015 is shown in Chart 1. The gross capacity loss of KRS Reservoir in 2014-2015 is presented in Table 3.



**Chart -1:** Change in Gross Capacity of KRS Reservoir

**Table -3:** Gross capacity Loss of KRS Reservoir in 2014-2015

Res. elevation (ft)	Original Area in 1932 (km <sup>2</sup> )	Revised Area in 2014-15 (km <sup>2</sup> )	Gross Vol. in 1932 (Mm <sup>3</sup> )	Gross Vol. in 2014-15 (Mm <sup>3</sup> )	Capacity loss in 2014-15 (Mm <sup>3</sup> )
80	40.97	37.94	315.82	255.54	60.286
85	47.705	43.309	383.31	301.69	81.622
90	55.324	52.456	461.70	382.59	79.113
95	63.732	58.616	552.40	469.20	83.192
100	72.789	69.005	656.31	563.25	93.066
105	82.637	79.673	774.62	672.51	102.107
110	93.414	88.556	909.30	796.56	112.736
115	105.027	99.476	1060.1	937.10	123.011
120	117.615	112.42	1229.6	1096.7	132.894
121.18	120.76	115.66	1279.4	1136.3	143.055

### 4. CONCLUSION

The remote sensing technique is reliable, quick and effective tool for the estimation of reservoir capacity and loss of capacity as compared to the conventional methods. Remote sensing technique with ERDAS software is easy, time saving and economical as it yields better results in a shorter period of time. The study concludes that the gross storage capacity of KRS reservoir for the year 2014-15 was 1136.394 Mm<sup>3</sup> against its original capacity of 1279.449 Mm<sup>3</sup> at 121.18 ft. The capacity loss of reservoir will be 143.055 Mm<sup>3</sup> from 1932 to 2014-15. The rate of sedimentation in the reservoir since first impoundment will be 1.744 Mm<sup>3</sup> per year. The assessment of reservoir capacity helps to ensure water security and also for the decision makers to take corrective measures to reduce silt load into the reservoir.

### ACKNOWLEDGEMENT

The authors thank the department of Karnataka Engineering Research Station, KRS road, Mandya for their valuable inputs and help rendered during the work.

**REFERENCES**

- [1] Goel, M. K., and Jain, S. K., 1996. Evaluation of reservoir sedimentation using multi-temporal IRS-1A LISS II data. *Asian Pacific Remote Sensing & GIS Journal*, 8 (2), pp. 39-43.
- [2] Hanumantha Rao G. and Viswanatham R., (1985). Project report on capacity evaluation of Sriramsagar reservoir using remote sensing techniques, Andhra Pradesh Engineering Research Laboratory, Hyderabad.
- [3] Jain, S.K., Singh, P., and Seth, S.M., 2002. Assessment of sedimentation in Bhakra Reservoir in the western Himalayan region using remotely sensed data. *Hydrological Sciences Journal*, 47 (2), pp. 203-212.
- [4] Jeyakanthan, V.S, Sanjeevi. S (2012). Capacity survey of Nagarjuna Sagar reservoir, India using Linear Mixture Model (LMM) approach.
- [5] R.K. Jaiswal, T. Thomas, R.V. Galkate, and S.K. Jain (2011) "Assessment of revised capacities and trend analysis of sedimentation in Reservoirs of southern Gujarat (India). *IJWREM: Volume 3, Number 2, July-December 2012*, pp. 155-165.
- [6] 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), pp. 1839 - 1850.
- [7] Shanker M. (2004). *Bulletin of National Natural Resources Management System (NNRMS)*, NRSA, Hyderabad.
- [8] Smith, S.E., Mancy, K.H. and Latif, A.F.A. (1980). The application of remote sensing techniques towards the management of the Aswan high dam reservoir. In: 14th Int. Symp. on Remote Sensing of Environment (San Jose, Costa Rica, 23-30 April 1980), 1297.
- [9] Bunyasi, M.M., Onywere, S.M. and Kigomo, M.K., 2013. Sustainable catchment management: assessment of sedimentation of Masinga Reservoir and its implication on the dam's hydropower generation capacity. *International Journal of Humanities and Social Science*, 3 (9), pp.166-179.
- [10] Gupta, S.C., 1999, Status paper on reservoir sedimentation assessment using remote sensing techniques. In: Proceeding national workshop on reservoir sedimentation assessment using remote sensing data. National Institute of Hydrology, Roorkee, India.
- [11] Goel, M. K., Jain, Sharad K. & Agrawal, P. K. (2002) Assessment of sediment deposition rate in Bargi reservoir using digital image processing. *Hydrol. Sci. J.* 47(Special Issue), S81-S92.