सत्यमेव जयते

उपग्रह दूरस्थ संवेदन द्वारा
इसापूर जलाशय, महाराष्ट्र का अवसादन आंकलन

SEDIMENTATION ASSESSMENT OF ISAPUR RESERVOIR, MAHARASHTRA, THROUGH SATELLITE REMOTE SENSING

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Government of India
Central Water Commission
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Remote Sensing Directorate

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Year of Study 2021
Data Used 2019-2021

STUDY TEAM

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EXECUTIVE SUMMARY

The dynamic aspects of the reservoir, mainly water spread, suspended sediment distribution and concentration requires periodical mapping and monitoring. Sedimentation in a reservoir has a bearing on the capacity of the reservoir as it affects both live and dead storages. In other words, the life of a reservoir depends on the rate of siltation. The satellite data provides opportunity to study these aspects on various scales and at different stages. The present report comprises of use of **Microwave Remote Sensed data** for the years 2019-21 in the sedimentation study of Isapur reservoir. The various aspects of the reservoir sedimentation, like the process of sedimentation in the reservoir, sources of sediment, measures to check the sediment and limitations of space technology have been discussed in the report.

Multi-date satellite remote sensing data provide information on elevation contours in the form of water-spread area. Any reduction in reservoir water spread area at a specified elevation corresponding to the date of satellite data is indicative of sediment deposition. The quantity of sediment load settled down over a period of time can thus be determined by evaluating the change in the aerial spread of the reservoir at various elevations.

In the present study **microwave data from Sentinel 1A/1B satellites** have been used to estimate water spread area of Isapur Reservoir. As compared to Optical remote sensing, Microwave remote sensing has advantages as the satellite operates day and night allowing the acquisition of imagery at frequent time intervals regardless of weather and illumination conditions. The Sentinel-1 mission is a constellation of two polar-orbiting satellites (Sentinel-1A and Sentinel-1B), with a C-band synthetic aperture radar instrument operating at a center frequency of 5.405 GHz, that acquires Synthetic Aperture Radar (SAR) data in single or dual polarization with a revisit time of 6 days.

Isapur dam was constructed in the year 1983 on the river Penganga in Pusad Taluk of Yeotmal district in Maharashtra. The original gross and live storage capacities of Isapur reservoir at the time of opening were 1279.06 MCM & 964.099 MCM respectively. These values were revised to 1241.537 MCM and 928.262 MCM respectively after detection of calculation error in original tables. No hydrographic survey has been done in the past for this reservoir. In 2003 Satellite Remote Sensing survey was done that reported the live capacity as 899.629 MCM.

After analysis of the satellite data in the present study, it is found that live capacity of Isapur reservoir in 2021 is 840.652 MCM witnessing a live storage loss of 87.610 MCM (i.e. 9.438%) in a period of 38 years during 1983 to 2021. This accounts for live capacity loss of 0.248% per annum since 1983.

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ABBREVIATIONS

CWC	Central Water Commission
DSL	Dead Storage Level
FRL	Full Reservoir Level
IRS	Indian Remote Sensing
LISS	Linear Imaging Self Scanner
MDDL	Minimum Draw Down Level
MSL	Mean Sea Level
MWL	Maximum Water Level
NIR	Near Infra-Red
NRSC	National Remote Sensing Centre
SAR	Synthetic Aperture Radar
SNAP	Sentinel Application Platform
SRS	Satellite Remote Sensing
N.A.	Not Available
WSA	Water Spread Area

UNITS USED

Cumec	cubic metre per second
M	Metre
M m^2	million square metre
M m^3/MCM	million cubic metre
Ha	Hectare
Sq Km	Square Kilometre
mm/year	millimetre per year

SEDIMENTATION ASSESSMENT OF ISAPUR RESERVOIR, MAHARASHTRA THROUGH SATELLITE REMOTE SENSING

1 INTRODUCTION

India – the second largest country in the world in terms of population – has about 17.3% of world's population, about 4% of world's water resources, and 2.44% of total geographical land area of the world. Therefore, in spite of having an average annual average precipitation to the tune of more than 1105 mm/year, the population density (lack of land resources) and per capita water resources availability make India a water-stressed country, as a whole. However, at a regional or basin level, many areas in the country are water-scarce or severely water-scarce owing to the spatial and temporal variability of water resources.

It is estimated that average annual precipitation over India is about 3880 BCM. Out of this precipitation, the average annual water resources availability of the country is about 1999.2 BCM, as estimated by Central Water Commission (CWC) in 2019. The water resources availability situation gets more murkier due to topographical and other constraints. Due to this, the total utilisable water resources in the country are about 1122 BCM (690 BCM of surface water and 432 BCM of groundwater). On one hand, the per-capita water resource availability is reducing due to increasing population and on the other, per-capita water usage is increasing due to industrialisation, urbanisation and change in lifestyles or dietary habits, making the available water resources still dearer.

India, has typical monsoon-based climate where more than 75% rainfall occurs in three months i.e. July, August, and September. The total number of rainy days typically are in the tune of only 20-25 days per year (100-150 hours of rain per year) for most parts of the country. As a result, the bulk of annual water (75-80%) in rivers is available only in these three months. Therefore, in order to sustain life and other activities throughout the year from a resources that is available only through 20-25 rainy days, it is absolutely essential to store the water in appropriately-sized storage structures (depending upon the topography and hydrology of the area).

So far, India has developed just 257.812 BCM as live storage capacity and 46.765 BCM is under construction. Realising the importance of storage structures, a large number of reservoirs have been built, since independence, during each plan in almost all river basins, except Ganga and Brahmaputra, to tap the available surface water and to utilize it as and when needed. The capacity of reservoirs is gradually reducing due to silting and hence sedimentation of reservoir is of great concern for all the water resources development projects.

Correct assessment of the sedimentation rate is essential for assessing useful life of the reservoir as well as optimum reservoir operation schedule. Since 1958, when it was established that the live storage of reservoir is getting reduced due to siltation, a systematic effort has been made by various departments / organizations to evaluate the capacity of reservoirs. Various techniques like boat echo sounder, etc. being replaced by hydrographic data acquisition system (HYDAC) and HITECH method using Differential Global Positioning System (DGPS). The conventional techniques are found either time consuming or costly and require considerable manpower. Remote sensing technique to calculate the present live capacity of reservoir is found to be very useful in this context due to its synoptic and repetitive coverage. The surveys based on remote sensing data are faster, economical and more reliable.

These surveys will enable selection of appropriate measures for controlling sedimentation along with efficient management and operation of reservoirs thereby deriving maximum benefits for the society.

This report covers the study of Isapur reservoir, Maharashtra by Central Water Commission, New Delhi.

2. SOURCES AND MECHANISM OF SEDIMENTATION

The principal sources of sediments are as follows:

1. Deforestation
2. Excessive erosion in the catchment
3. Disposal of industrial and public wastes
4. Farming
5. Channelisation works
6. Human activities
7. Land development, highways, and mining

The sedimentation is a product of erosion in the catchment areas of the reservoir and hence lesser the rate of erosion, smaller is the sediment load entering the reservoir. Various factors govern the erosion, transport and deposition of sediment in the reservoir. Type of soil, drainage density, vegetation, rainfall intensity and duration, shape of catchment and land use /land cover affect the erosion. Sediment transportation depends upon slope of the catchment, channel geometry and nature of riverbank and bed. Deposition is a function of bed slope of the reservoir, length of reservoir, flow patterns, inflow - outflow rates, grain size distribution, mode of reservoir operation, etc.

In order to obtain the knowledge of sedimentation in the reservoir, it is necessary to study the mechanism of sedimentation, which will help to mitigate reservoir sedimentation, prolong the life span of reservoirs and to take full benefits of reservoirs. The sediment deposition in a reservoir depends on the following:

- Longitudinal and lateral valley shape
- Length and shape of reservoir
- Flow patterns in reservoir
- Capacity to inflow volume ratio (trap efficiency)
- Grain size distribution of sediment
- Water and sediment discharges
- Mode of reservoir operation
- Nature of incoming floods

Reservoirs created by dams on rivers lose their storage capacity due to sedimentation. As water enters a reservoir, its velocity diminishes because of the increased cross-sectional area of the channel. If the water stored in the reservoir is clear and the inflow is muddy, the two fluids have different densities and the heavy turbid water flows along the channel bottom towards the dam under the influence of gravity (Fig 1). This condition is known as "stratified flow" and the underflow is called a "density current". A large proportion of the transported silt eventually gets deposited at different levels of a reservoir and causes reduction not only in dead storage but also in live storage capacities.

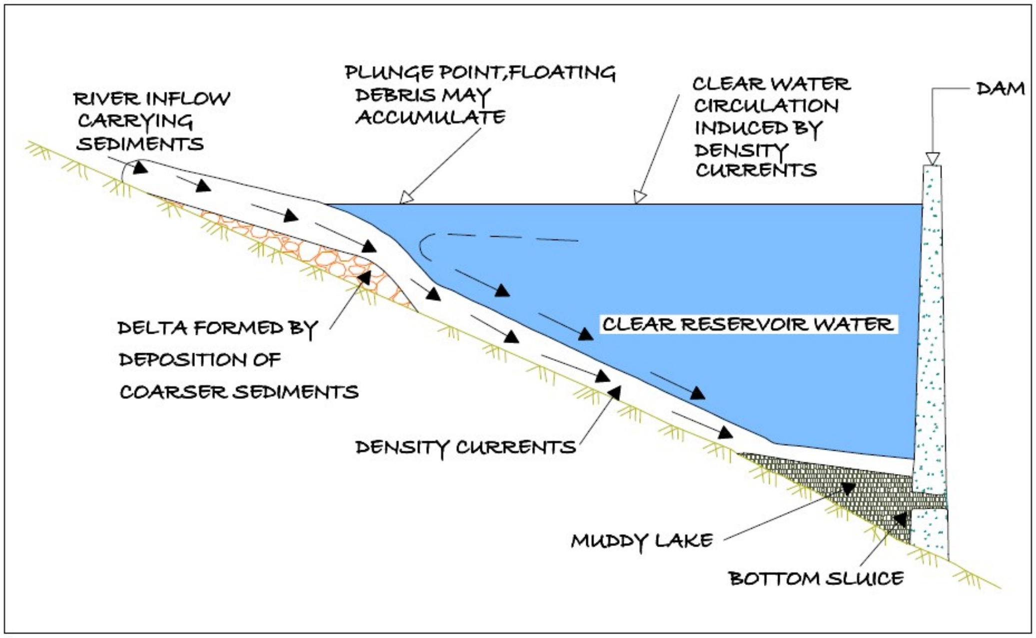


Fig. 1: Conceptual sketch of density currents in a reservoir

Earlier it was believed that sediment always gets deposited in the bottom elevations of reservoir affecting the dead storage rather than depositing throughout the full range of reservoir depth. It is now fully realized that deposition takes place throughout the reservoir reducing the incremental capacity at all elevations.

Longitudinal deposition patterns in the reservoir will vary from one reservoir to another as influenced by pool geometry, discharge and grain size characteristic of the inflowing load and reservoir operation. There can be four types of depositing patterns in the reservoir as shown in the fig 2.

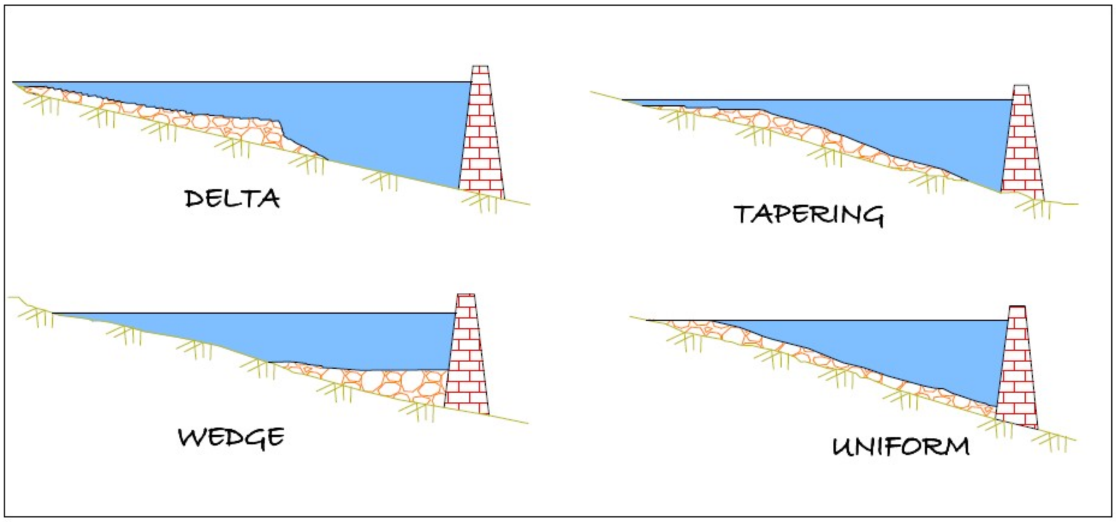


Fig. 2: Longitudinal Patterns of sediment deposition in reservoirs.

Delta deposits contain the coarsest fraction of the sediment load, which is rapidly deposited at the zone of inflow. It may consist entirely of coarse sediment or may also contain a large fraction of finer sediment such as silt. Wedge-shaped deposits are thickest at the dam and become thinner moving upstream. This pattern is typically caused by the transport of fine sediment to the dam by turbidity currents. Wedge- shaped deposits are also found in small reservoirs with a large inflow of fine sediment, and in large reservoirs operated at low water level during flood events, which causes most sediment to be carried into the vicinity of the dam. Tapering deposits occur when deposits become progressively thinner moving toward the dam. This is a common pattern in long reservoirs normally held at high pool level, and reflects the progressive deposition of fines from the water moving toward the dam. Uniform deposits are unusual but do occur. Narrow reservoirs with frequent water level function and small load of fine sediment can produce nearly uniform deposition depths. Several factors like amount of sediment load, size distribution, fluctuations in stream discharge, shape of reservoir, stream valley slope, vegetation at the head of the reservoir, location and size of reservoir, outlets, etc., control the location of sediment deposits in the reservoir.

Figure 3 shows different levels in the reservoir where-in the capacity is affected. Reservoirs operate between Minimum Draw Down Level (MDDL), which is at sluice level to Full Reservoir Level (FRL), which is at dam level. The storage between these two levels is the live storage as shown in Fig. 3. The storage below MDDL is the dead storage. Water stored along the valley bed is known as valley storage.

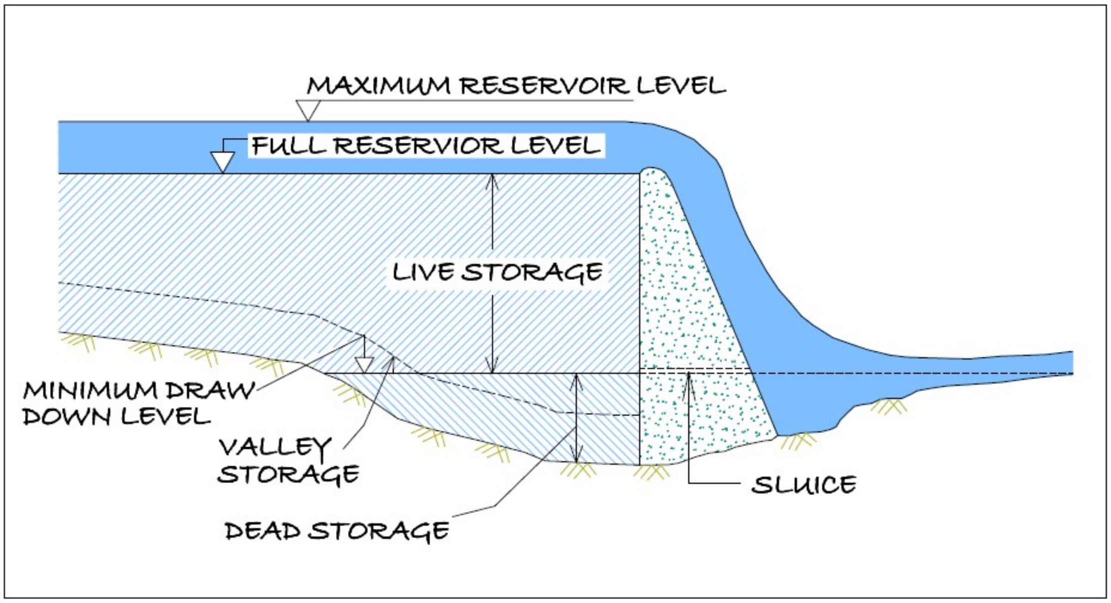


Fig. 3: Conceptual sketch of different levels in a reservoir

3. CONTROL OF SEDIMENTATION

Due to the multiple variables involved in reservoir sedimentation, no single control measure can be considered as the most effective. The measures, which can be employed to limit sedimentation and turbidity, are as under:

1. Soil and water conservation measures within the drainage basin, contour ploughing, strip cropping, suitable farming practices, improvement of agricultural land, construction of small dams/ponds/terraces/check dams on gullies
2. Revetment and vegetation cover
3. Evacuation of sediment
4. Reservoir shoreline protection
5. Stream bank and flood plain protection
6. Ridge plantation such as pasture development and reservoir shoreline protection

Silting not only occurs in the dead storage but also encroaches into the live storage zone, which impairs the intended benefits from the reservoirs. Therefore, the problem of sedimentation needs careful consideration. Adequate provision has to be made in the reservoir for accumulation of anticipated quantities of silt. Steps are also required to be taken to ensure that the storage capacities available are not lost or get reduced by accelerated sedimentation.

4. REMOTE SENSING IN RESERVOIR SEDIMENTATION

Remote sensing is the art and science of collecting information about earth's feature without being in physical contact with it. Various features on earth surface reflect or emit electromagnetic energy depending upon their characteristics. The reflected radiation depends upon physical properties of the terrain and emitted radiation depends upon temperature and emissivity. The radiations are recorded by the sensor on-board satellite and then are transmitted back to earth. Difference between features depends on the fact that response from different features like vegetation, soil, water is different and discernable. Data received at ground stations, is digitally or visually interpreted to generate thematic maps.

The data from satellites such as Landsat, SPOT and IRS are useful for mapping and monitoring the surface water bodies and other land resources based on which, better water management strategies could be planned. Data from microwave remote sensing technique such as SENTINEL-1 is more useful as it is an imaging radar mission providing continuous all-weather, day-and-night imagery at C-band. The SENTINEL-1 constellation provides high reliability, improved revisit time, geographical coverage and rapid data dissemination to support operational applications in the priority areas of marine monitoring, land monitoring and emergency services.

Spectral response of water is affected by variables like time of the year, sun elevation angle, water vapour content in the atmosphere, roughness of water surface, water colour, turbidity, type and concentration of suspended particles, depth of water, characteristics of bottom material and submerged or emergent vegetation.

Reservoir sedimentation surveys are essentially based on mapping of water-spread area at the time of satellite over pass. Multi-date satellite data is needed which covers the operating level of reservoir at close interval. Water spread area is nothing but water level contour at that level. Using different contours, capacity between them is calculated. With the sedimentation, the water spread area of the reservoir reduces at different levels. The water spread area and the elevation information is 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 the change in capacity between different levels.

Remote Sensing based reservoir capacity estimation has certain limitations. The capacity estimation works between MDDL and FRL only as these are the levels between which reservoir operates. Thus changes can be estimated only in live capacity of reservoir. For capacity estimation below MDDL corresponding to dead storage other methods like hydrographic survey are to be used. Availability of cloud free data throughout reservoir operations that was a limitation in earlier optical analysis has been taken care of by using microwave datasets that are not affected by weather or illumination conditions. This technique gives accurate estimates for fan shaped reservoir where there is a considerable change in water spread area with change in water level.

5. OBJECTIVES

The objective of the study is to estimate live capacity loss of Isapur reservoir due to sedimentation through Satellite Remote Sensing. Following objectives will be achieved in the study.

a) Updation of Elevation - Area - Capacity curve using satellite data in live storage zone.
b) Estimation of storage loss due to Sedimentation.

6. STUDY AREA

Penganga river rises at an altitude of 685.8m form Buldhana range near Deolghat in Buldhana district of Maharashtra. After flowing in south easterly direction, it forms a boundary between Vidharbha and Marathwada regions. Except in its upper most reach of about 160km, which is mostly barren and hilly, the river passes through dense forests of Yeotmal and Nanded districts. The biggest tributary of Penganga on the southern side is Kayadhu river. The prominent rivers which join Penganga on the North are pus, Aran, Waghari and Khuni. Isapur dam was constructed in the year 1983 on the river Penganga in Pusad taluk of Yeotmal district in Maharashtra at latitude 19°43' N and longitude 77°27' E. Figure 4 shows the index map of Isapur reservoir.

The total catchment area of the reservoir is 4650 sq. km. Project has a designed gross storage capacity of 1279.06 MCM with live capacity being 964.09MCM. These values were revised to 1241.537 MCM and 928.262 MCM respectively after detection of calculation error in original tables. FRL of the dam is at 441 m with MDDL at 426.16m. Isapur dam is a masonry dam with 3.870km long earthen portion and 0.218m as masonry portion. There are 15 gates of size 12.0m x 6.5m and they are of vertical lift type. Study area has a designed rate of siltation in gross capacity as 0.357mm/year. Salient features of the Isapur project are given in Annexure 1.

7. APPROACH FOR PRESENT STUDY

Remote Sensing technique makes use of water-spread of the reservoir between maximum and minimum operating level during the observation period. Since the reservoir levels generally do not go below the MDDL, water spread observations are not possible below MDDL. The same are to be extrapolated from observed elevation-area curve to find out capacity below MDDL. In the case of Isapur reservoir, the height difference between FRL (441 m) and MDDL (426.16 m) is 14.84 m.

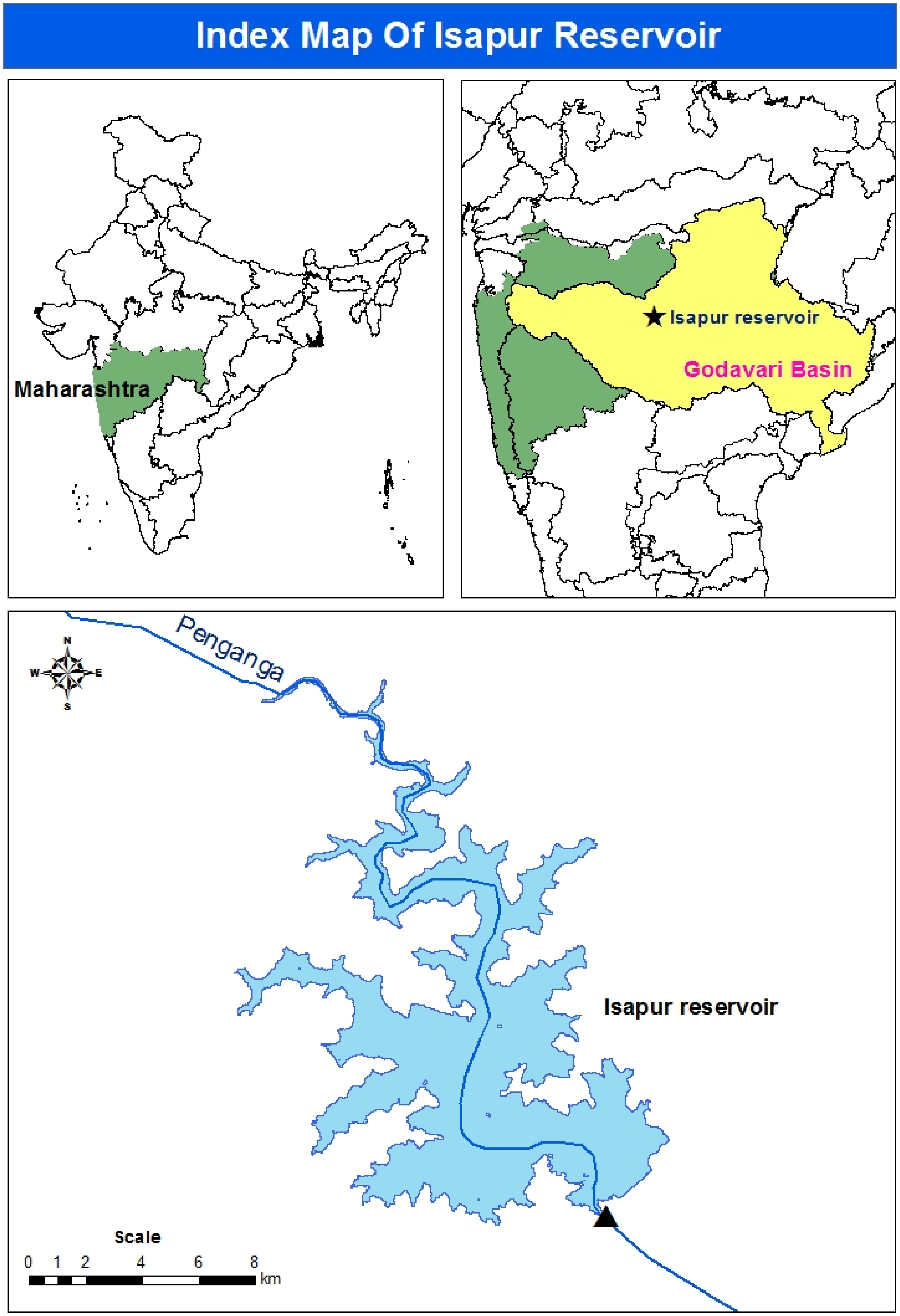


Fig. 4: Index map of the Isapur Reservoir

8. DATA USED

8.1. SATELLITE DATA

Microwave data from Sentinel 1A/1B for eight (08) dates has been used in the analysis. Table 1 depicts the date of pass of satellite along with elevation observed on that date.

Table – 1: Date of pass for satellite data

Satellite	Date of pass	Elevation (m)
Sentinel 1A	16-07-2019	426.16
Sentinel 1A	21-08-2019	429.25
Sentinel 1B	20-09-2019	430.82
Sentinel 1A	28-06-2020	433.76
Sentinel 1A	03-08-2020	435.80
Sentinel 1A	24-01-2020	437.90
Sentinel 1A	06-01-2021	439.89
Sentinel 1A	07-11-2020	441.00

8.2. FIELD DATA

The following field data have been obtained from project authorities:

Elevation - Capacity data

Salient features of Isapur reservoir levels and capacity data on specified dates

9. METHODOLOGY

Digital analysis has an edge over visual analysis in identifying water spread and turbidity levels in detail and more accurately because of minimizing human error or subjectivity. For Isapur reservoir studies, multi-date Sentinel 1 (08 nos. imageries) is used for the analysis. Image processing with SNAP software and Arc GIS software was used for the analysis. The analysis comprised,

- Geo-referenced Data base.

- Water spread area estimation.
- Estimation of reservoir capacity.
- Comparison with original capacity.

9.1. DATA BASE

The satellite data from Sentinel 1 satellite corresponding to reservoir area obtained from Copernicus open access hub was loaded on the system. The Sentinel-1 mission is a constellation of two polar-orbiting satellites (Sentinel-1A and Sentinel-1B), that operate day and night, sensing with a C-band synthetic aperture radar instrument operating at a centre frequency of 5.405 GHz, allowing the acquisition of imagery regardless of weather and illumination conditions. Sentinel-1 satellite constellations acquire Synthetic Aperture Radar (SAR) data in single or dual polarization with a revisit time of 6 days. A series of standard corrections was applied to the data using SNAP software to apply a precise orbit of acquisition, remove thermal and image border noise, perform radiometric calibration, and apply range Doppler and terrain correction.

9.2. WATER SPREAD AREA ESTIMATION

Reduction in capacity of reservoir at different levels is depicted by reduction in water-spread area (WSA) at different water levels. Estimation of water-spread area is done using various digital image processing (DIP) techniques. The technique adopted for water-spread area estimation are as follows:

- SAR data Pre-processing using Sentinel Application Platform (SNAP)
- Thresholding using ARC-GIS

9.2.1. SAR DATA PRE-PROCESSING USING SNAP

The open-source Sentinel Application Platform (SNAP) Toolkit developed by European Space Agency was used for SAR data pre-processing. Sentinel-1 intensities from high-resolution Level-1 ground range detected products (10 m; GRDH) were calibrated, speckle-filtered, and geometrically corrected using Range Doppler Terrain Correction. Specifically, the improved Lee-Sigma single product speckle filter with a window size of 7 by 7 was used to reduce speckle noise. Terrain correction were conducted using the recently released STRM 1 arc-second HGT digital elevation model (DEM) and UTM/WGS84 (Automatic) Map projection was used wherein SNAP automatically selects the required UTM zones.

9.2.2. THRESHOLDING

The areas where clear water/land demarcation is there, density slicing is successfully used for delineation of water spread areas. Density slicing is a technique where the entire grey values of pixels occurring in the image are divided into a series of specified intervals. All the grey values falling within a range are grouped in one grey value, which is displayed in output. This process divides the image into water and land pixels. From the study of histogram peaks, minimum and maximum value for water pixels is identified and image is then density sliced.

Water spread areas are extracted for all the scenes. Fig 5 shows the flowchart of methodology, Fig. 6 shows Sentinel 1A/1B images of different dates and Fig. 7 shows the superimposed reservoir water spreads for different dates. Water spread area has been calculated by multiplying number of pixels with area of each pixel i.e. (10m x 10m) in case of Sentinel 1 imagery. Table 2 shows satellite-derived reservoir water spread areas for different satellite overpass dates along with the water levels of the reservoir at the corresponding dates collected from the project authtorites.

Table – 2: Water Spread Areas estimated from Satellite Images

Date of pass	Elevation (m)	Area (Mm^2)
16-07-2019	426.16	31.492
21-08-2019	429.25	38.297
20-09-2019	430.82	43.564
28-06-2020	433.76	56.378
03-08-2020	435.80	63.995
24-01-2020	437.90	79.091
06-01-2021	439.89	85.550
07-11-2020	441.00	90.298

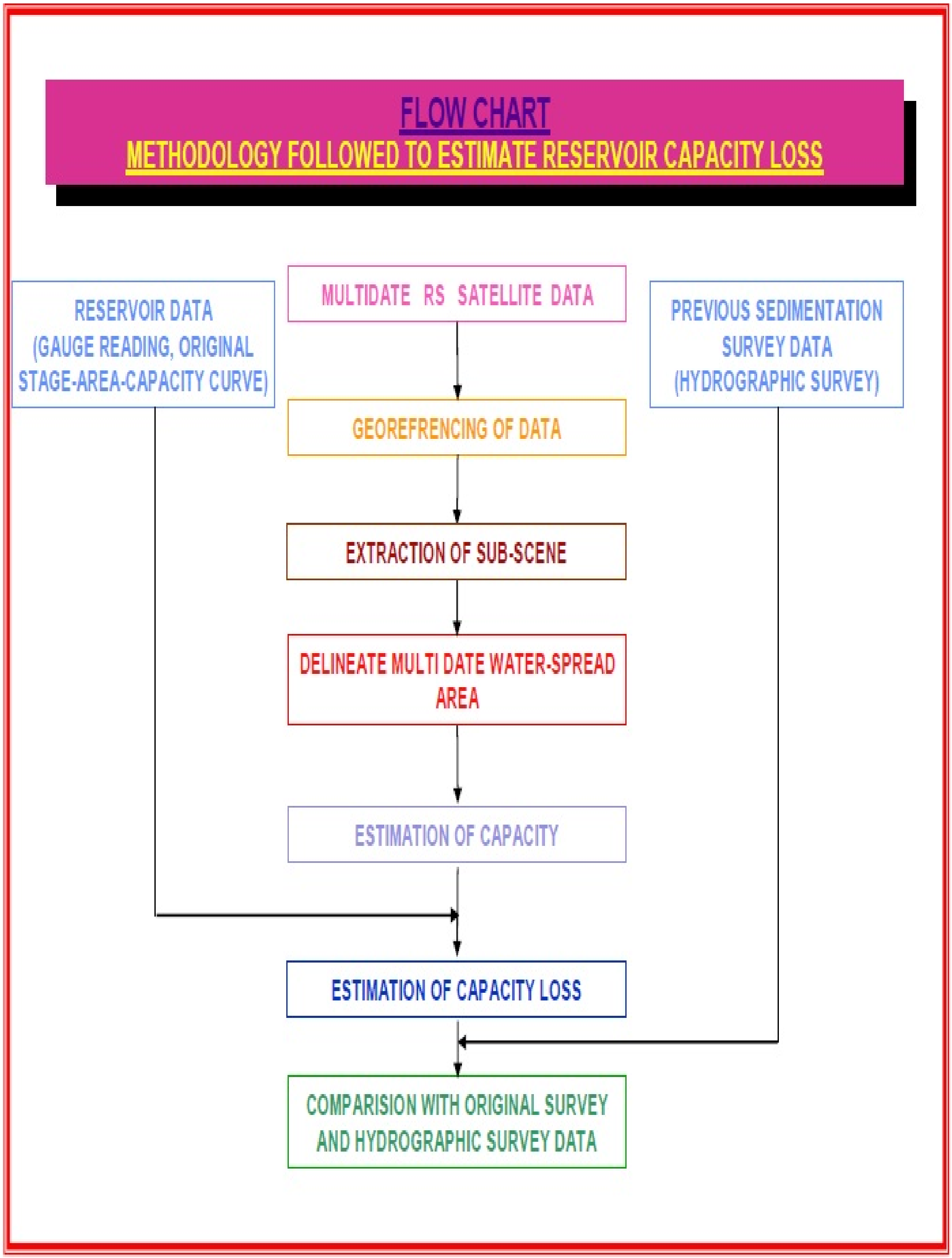


Fig 5 : Flow chart showing methodology followed to estimate reservoir capacity loss

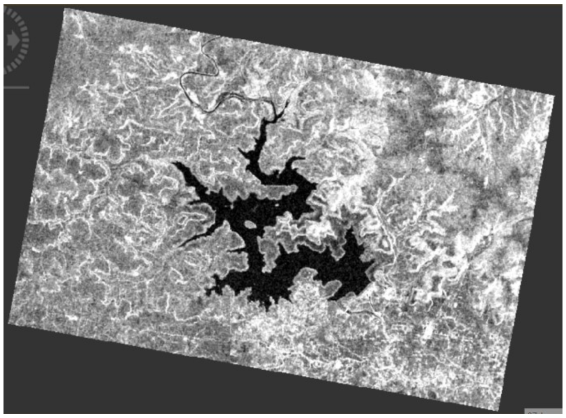
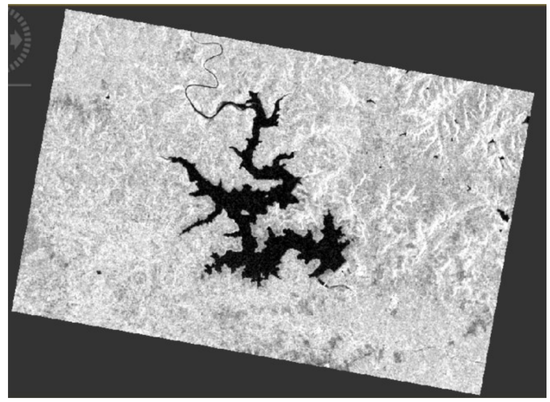
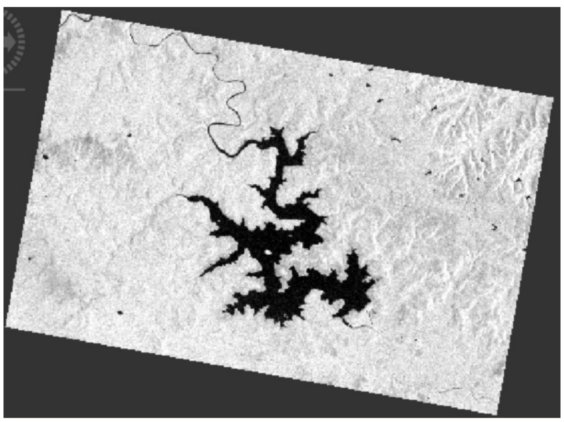
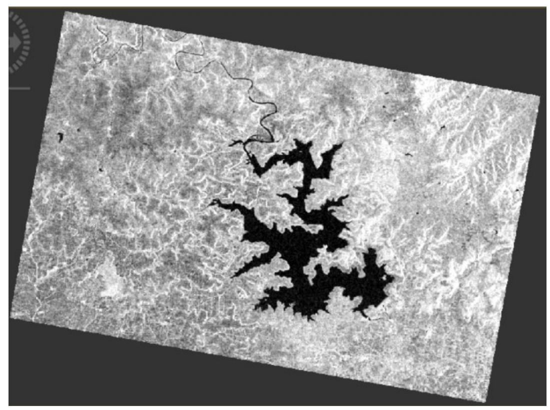
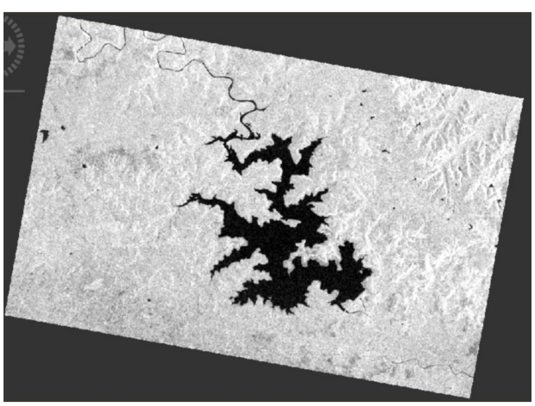
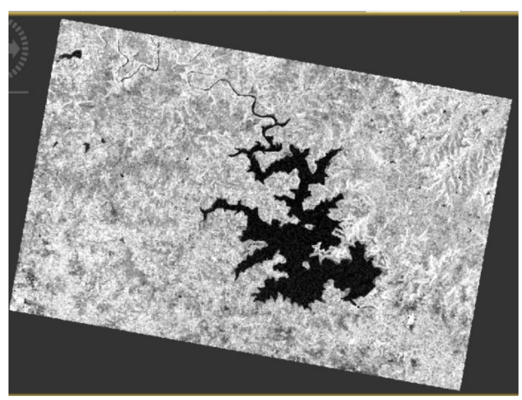
	
16-July-2019 (426.16 m)	**21-Aug-2019 (429.25 m)**
	
20-Sept-2019 (430.82 m)	**28-June-2020 (433.76 m)**
	
03-Aug-2020 (435.80 m)	**24-Jan-2020 (437.90 m)**

Fig 6 : Sentinel 1 SAR imageries showing water spreads at different dates (Isapur Reservoir)

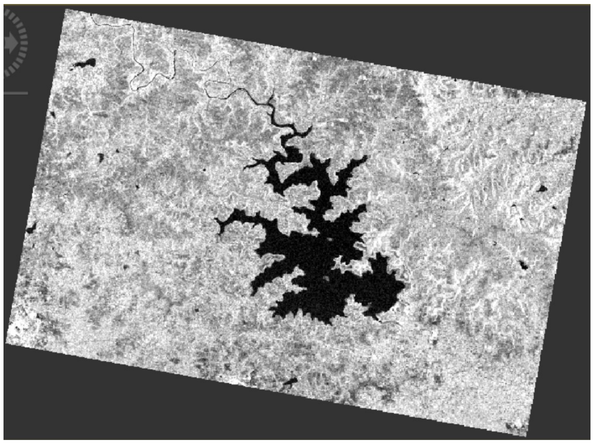
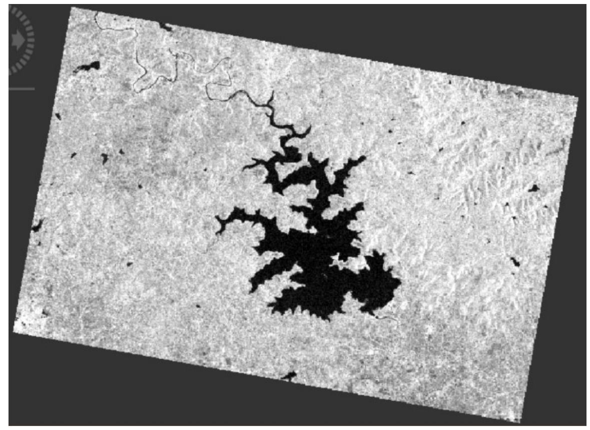
	
06-Jan-2021(439.89 m)	**07-Nov-2020 (441.00 m)**

Fig 6 : Sentinel 1 SAR imageries showing water spreads at different dates (Isapur Reservoir)

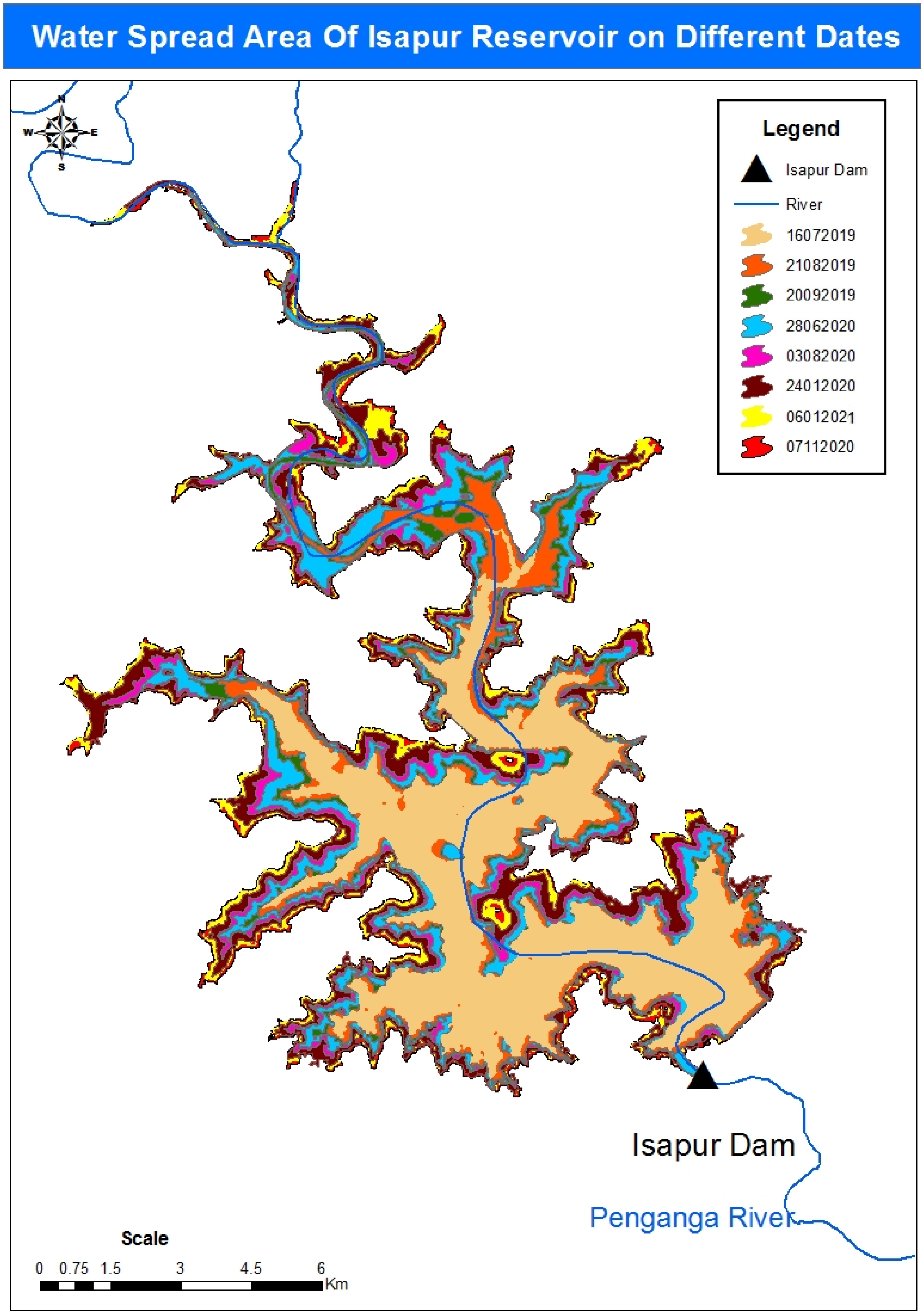


Fig. 7: Water Spread Area of Isapur Reservoir on different dates

The Satellite Images for the Isapur reservoir have been obtained from Copernicus Open Access Hub that provides complete, free and open access to all sentinel mission data. The analysis has been carried out using **Sentinel Application Platform** (SNAP) and Digital Image Processing software Arc GIS. The digitally processed images of Isapur Reservoir showing its water spread area for eight overpass dates such as 07-Nov-2020, 06-Jan-2021, 24-Jan-2020, 03-Aug-2020, 28-Jun-2020, 20-sept-2019, 21-Aug-2019 and 16-July-2019 are shown in fig. 7.

The water elevation 441 m for 07-Nov-2020 is at the Full Reservoir Level (FRL). The Water elevation 426.16 m for 16-July-2019 is at the Minimum Drawdown Level (MDDL).

9.3. ESTIMATION OF RESERVOIR CAPACITY

Area elevation curve has been plotted using these above eight (8) water-spread areas for different water level in the reservoir and best-fit polynomial equation of second order as given below have been derived.

$Y = 0.105*X^2 + 2.5589 * X + 29.948$

$R^2 = 0.9936$

Where, X is Elevation in meters

Y is Water Spread Area in M Sqm

Elevation - area curve using this equation has been plotted and shown in Fig-8. Water spread areas derived from satellite data for various dates are also marked on the curve. Computation of the reservoir capacity at various elevations was made using following formula

$$V = h/3\{A1+A2 + \text{sqrt.}(A1*A2)\}$$

Where,

'V' is the reservoir capacity between two successive elevations h1 and h2,

'h' is the elevation difference (h1-h2),

'A1 & A2' are areas of reservoir water spread at elevations h1 & h2.

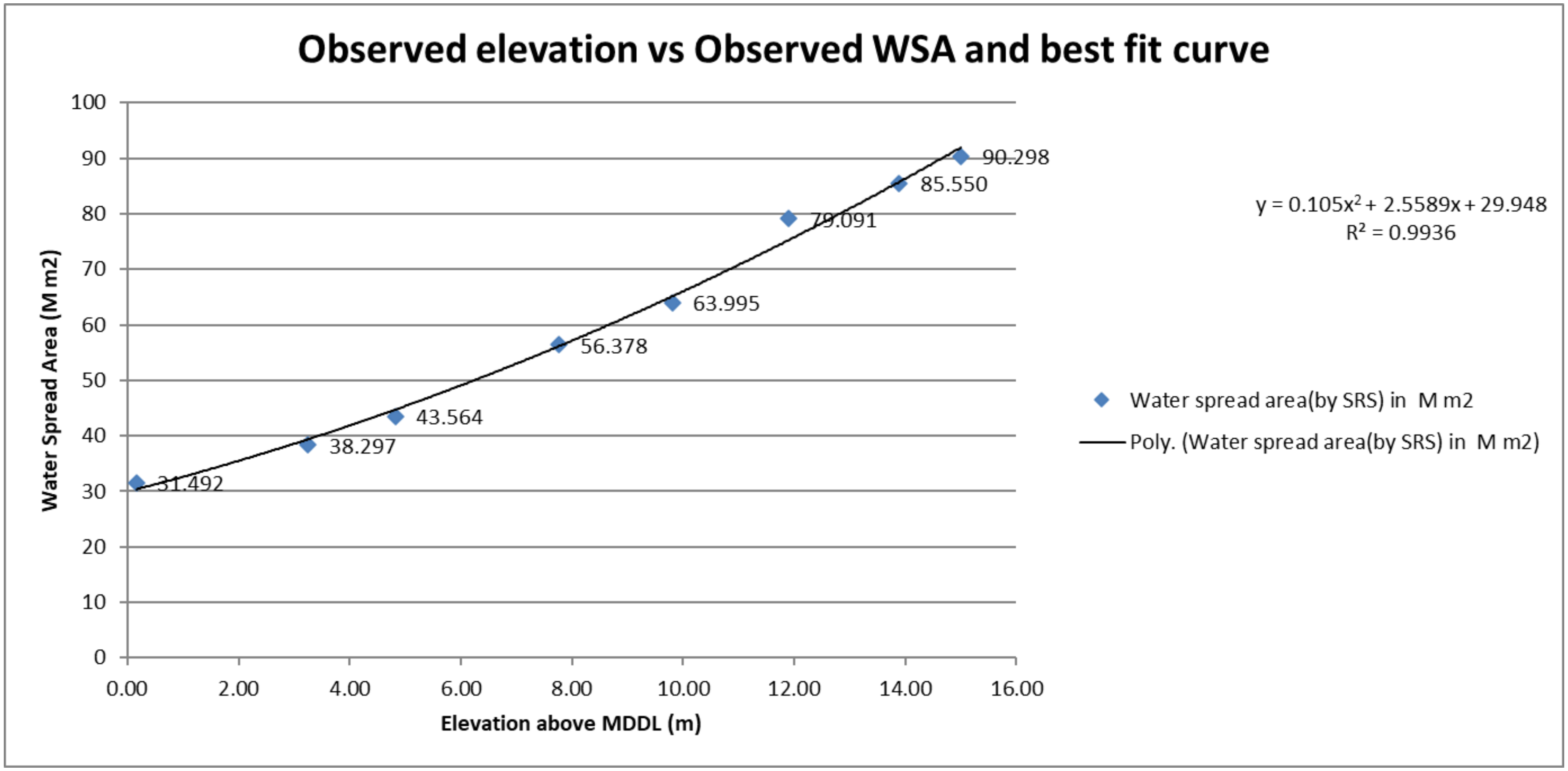


Fig. 8: Observed elevation vs Observed WSA of Isapur Reservoir

Table 3 gives the values of Live storage capacity and submergence areas at a regular interval of 1.0 m have been worked out using the best-fit polynomial equation at different elevations.

The Observed water level versus observed water spread area is at Fig-8. Modified live capacity - elevation curve and modified elevation – area –capacity curves are plotted and shown in Fig-9 and Fig-10 respectively.

Table-3: Aerial extent of reservoir at regular interval (1.0m) using SRS Survey 2021

Reservoir water level in Metre		Water spread area by trend line (Mm^2)	Segmental Live Capacity (MCM) by SRS technique	Cumulative Live Capacity (MCM) by SRS technique 2021
MDDL	**426.16**	29.948	0.000	0.000
	427.00	32.172	26.085	26.085
	428.00	35.012	33.582	59.666
	429.00	38.062	36.526	96.193
	430.00	41.322	39.681	135.874
	431.00	44.793	43.046	178.920
	432.00	48.473	46.621	225.541
	433.00	52.363	50.406	275.946
	434.00	56.464	54.401	330.347
	435.00	60.774	58.606	388.953
	436.00	65.294	63.021	451.973
	437.00	70.025	67.646	519.619
	438.00	74.965	72.481	592.100
	439.00	80.115	77.526	669.625
	440.00	85.475	82.781	752.406
FRL	**441.00**	91.046	88.246	**840.652**

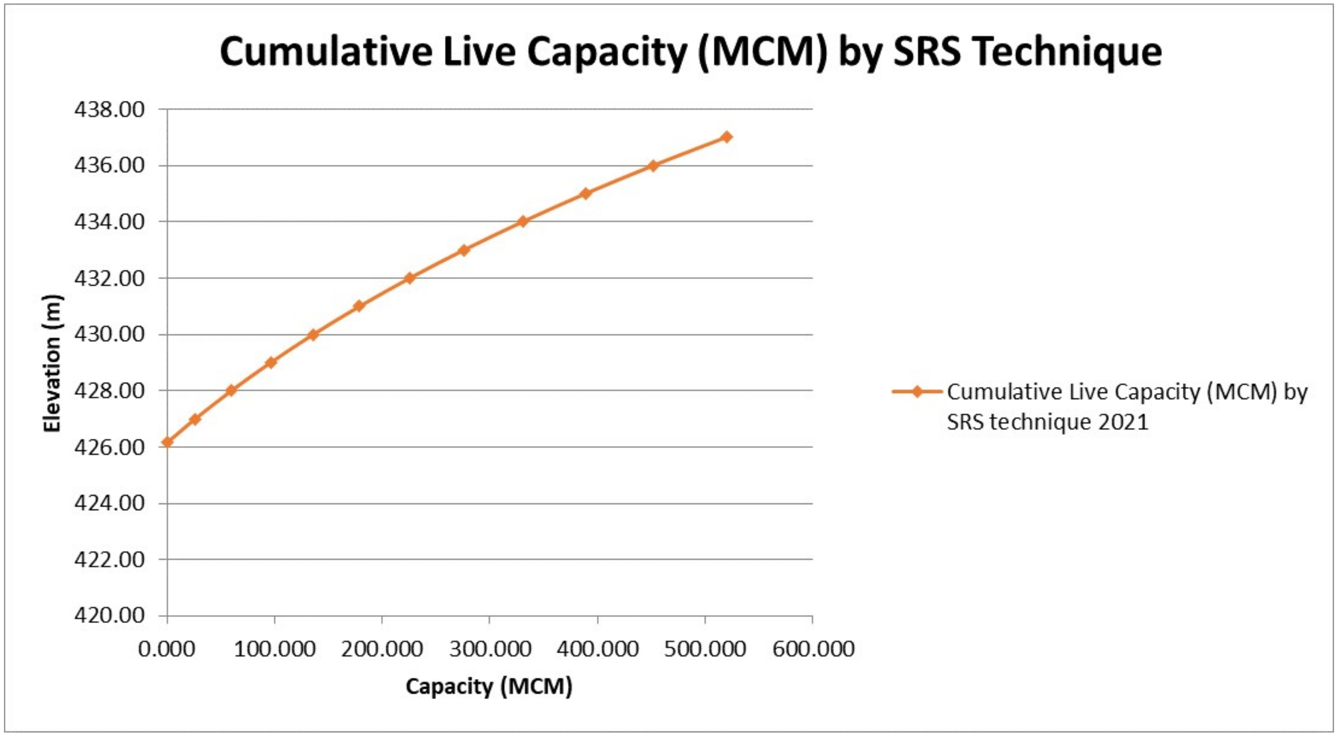


Fig. 9: Modified live capacity - elevation curve (SRS technique) : Isapur Reservoir

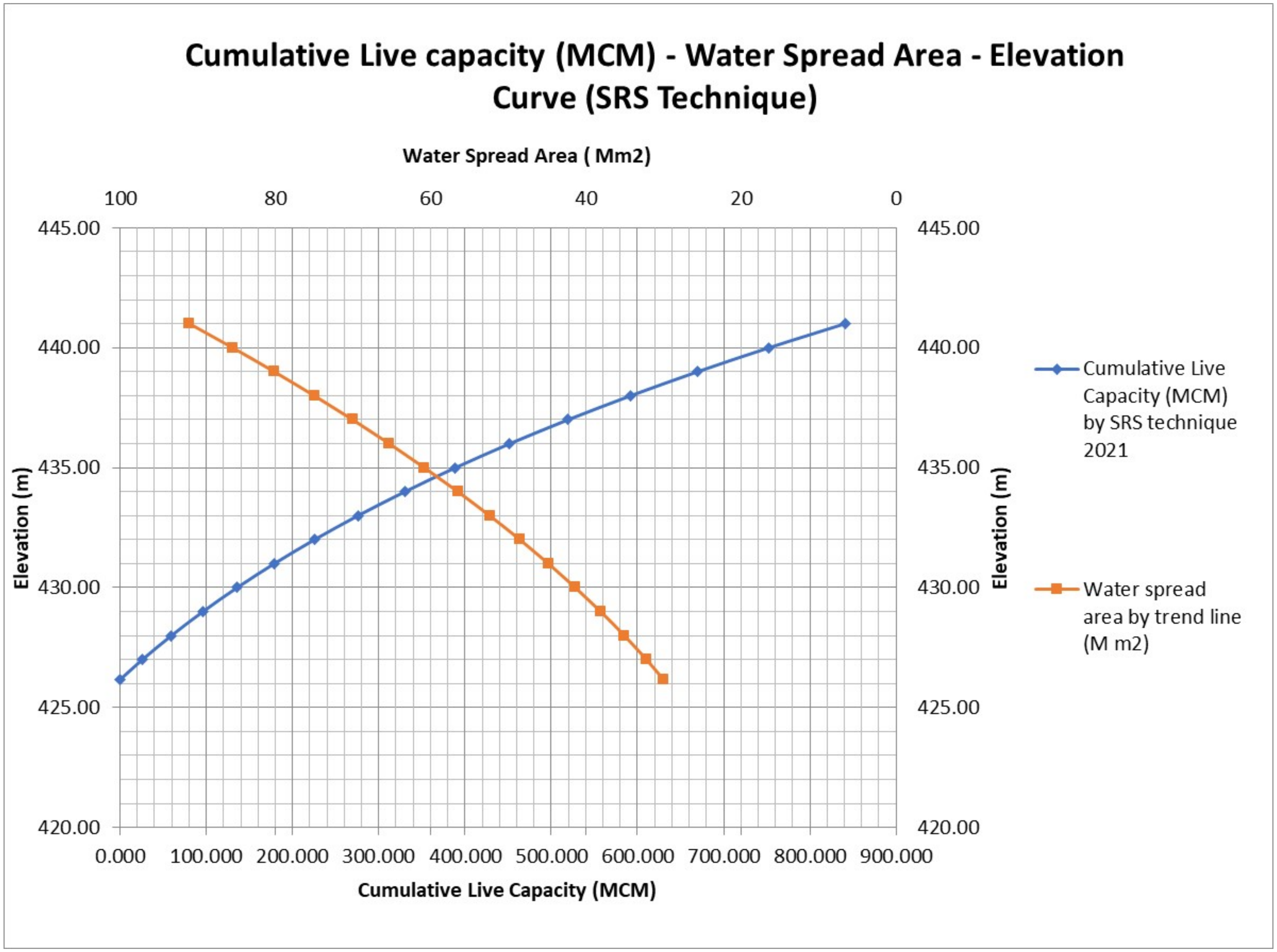


Fig. 10: Elevation – Area- Capacity Curve (Isapur Reservoir)

9.4. Comparison with Original and Previous Surveys

Comparison of live storage capacity of SRS survey with original survey 1983, and SRS survey 2003 at various elevations is given below in table 4. Curve showing comparison of live capacity is drawn in figure 11.

Table-4: Comparison of Live Storage Capacity (MCM)

Elevation (m)	Original Live Capacity (MCM) 1983	Cumulative live capacity by SRS survey (MCM) 2003	Cumulative live capacity by SRS survey (MCM) 2021
426.16	0	0.000	0.000
427.00	37.005	34.8785	26.085
428.00	76.310	72.6844	59.666
429.00	117.983	113.57	96.193
430.00	162.130	157.686	135.874
431.00	209.736	205.185	178.920
432.00	261.343	256.218	225.541
433.00	317.115	310.938	275.946
434.00	377.212	369.497	330.347
435.00	441.783	432.045	388.953
436.00	510.850	498.735	451.973
437.00	584.525	569.719	519.619
438.00	662.954	645.149	592.100
439.00	746.289	725.176	669.625
440.00	834.676	809.952	752.406
441.00	**928.262**	**899.629**	**840.652**

The original gross and live storage capacity of Isapur reservoir in 1983 were reported as 1241.537 MCM & 928.262 MCM respectively.In 2003, a Satellite Remote Sensing Survey was conducted using optical imageries that indicated a live storage capacity of 899.629 MCM.

In the present study, it is found that live capacity of the Isapur reservoir in 2021 is 840.652 MCM witnessing a live storage loss of 87.610 MCM (i.e. 9.438 %) in a period of 38 years during 1983 to 2021. This accounts for live capacity loss of 0.248% per annum since 1983.

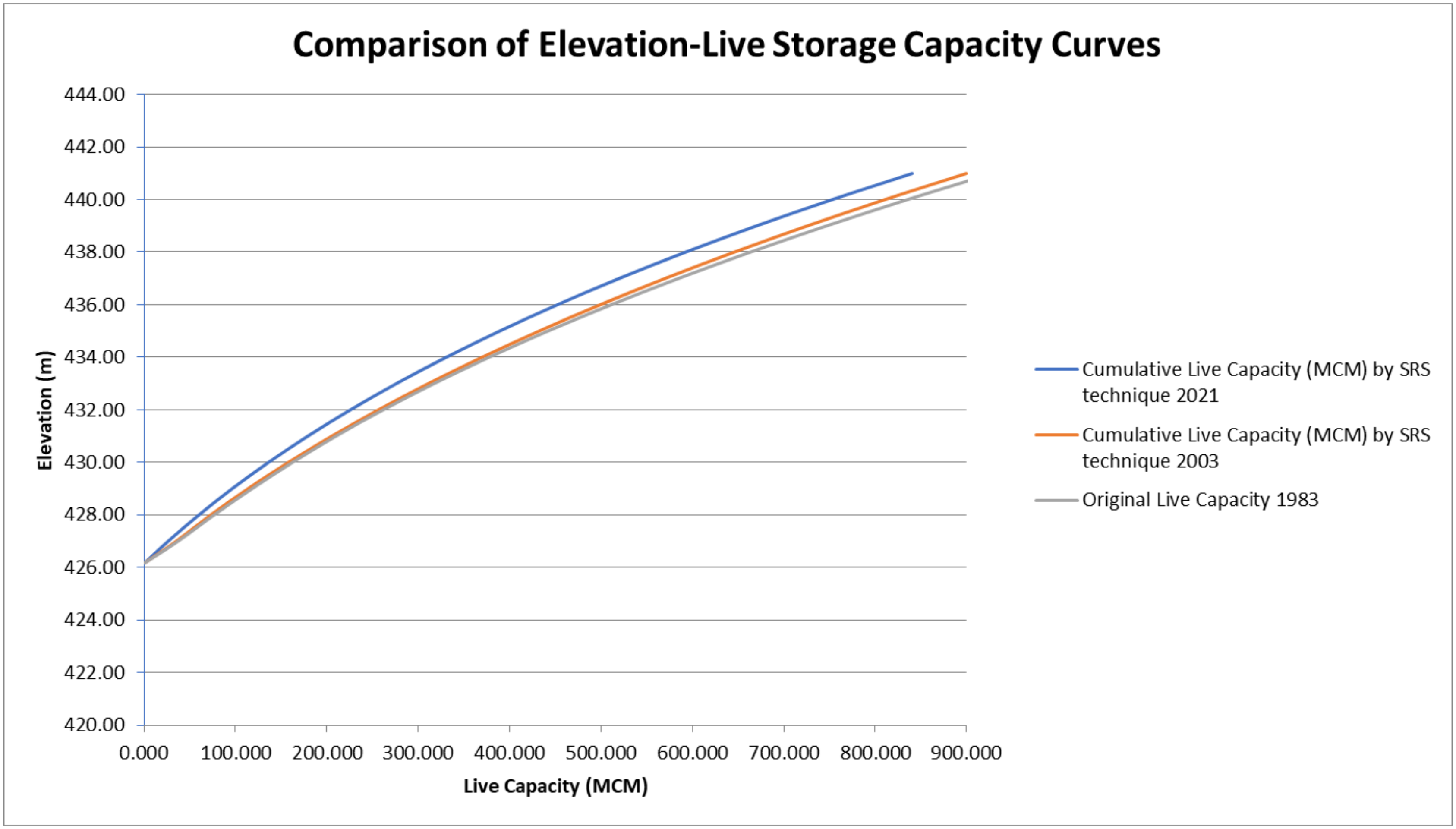


Fig. 11: Comparison of Elevation-Live Storage Capacity Curves (MCM): Isapur Reservoir

10. RESULTS AND DISCUSSIONS

The loss in live storage capacity of the reservoir due to sedimentation since original survey (1983), and remote sensing survey (2003) is given in Table –5.

Table – 5 : Storage Capacity loss due to sedimentation as per previous surveys

	Original Survey (1983)	SRS (2003)	SRS (2021)
Live Capacity (MCM)	928.262	899.629	840.652
Loss in Capacity (MCM) (since 1983)	-	28.633	87.610
% Live capacity loss between two consecutive surveys (of the original capacity)	-	3.085%	6.353%
% Live capacity loss (since impoundment in 1983)	-	3.085%	9.438%
Annual % live capacity loss	-	0.154%	0.248%

The live storage capacity of Isapur reservoir as per present study is found to be 840.652 MCM for the year 2021. As per original survey conducted in 1983 the live storage capacity was 928.262 MCM. In 2003 Remote sensing survey, the capacity was worked out as 899.629 MCM.

Modified elevation-area-capacity table worked out by the present study is given at Table 3.

11. CONCLUSION

The following conclusions emerge from the present study, subject to the limitations stated in following paragraphs.

1. The live storage capacity of Isapur reservoir has been found to be 840.652 MCM in 2021.
2. Live storage loss of 87.610 MCM (i.e. 9.438%) was observed since original survey (1983) i.e. in a period of 38 years. This accounts for live capacity loss of 0.248% per annum since 1983.

3. Satellite remote sensing based survey gives the information on the capacities in the water level fluctuation zone only, which generally lies between MDDL and FRL of the reservoir. Use of Satellite Remote Sensing technique enables a fast and economical estimation of live storage capacity loss due to sedimentation.
4. Capacity estimation by this technique at regular time interval can give important parameters like annual rate of sedimentation and sediment deposition pattern in the reservoir area and provide new elevation - area - capacity curve for optimal operation of the reservoir.
5. **Capacity estimation using Microwave remote sensing technology has the advantage that cloud-free imageries are available throughout the year at frequent interval as they are not affected by weather or illumination conditions.**

12. LIMITATIONS/OBSERVATIONS

1. As the reservoir operates between MDDL and FRL, the satellite data is available for this range only. The satellite remote sensing based reservoir capacity estimation works between MDDL and FRL in live storage.
2. Remote sensing techniques give accurate estimate for fan shaped reservoir where there is considerable change in water-spread area with change in water level.
3. Ground truth verification of boundary pixels is not possible due to continuous variation in reservoir levels that prevents correlating field observation of reservoir boundary with satellite data.

Annexure-I

1. General

Reservoir Location

a.	State	Maharashtra
b.	District	Yeotmal
c.	Taluka	Pusad
d.	Village	Isapur
e.	River	Penganga
f.	Latitude	$19^o43'$N
g.	Longitude	$77^o27'$E
h.	Nearest Railway Station	Nanded (85 km), Hongoli (45km)
i.	Nearest all weather road	Pusad-Nanded (5 km)
j.	Distance from Taluka HQ	35 km
k.	Distance from District HQ	45 km from Hingoli

2. Dam Details

a.	Catchment Area	4650 Mm^2
b.	Gross Capacity (revised)	1241.537 MCM
c.	Live Capacity (revised)	928.262 MCM
d.	Height of Dam	48 m
e.	Length of Dam – Earthen	3870 m
f.	Length of Dam – Masonry	218 m
g.	Type of Dam	Masonry
h.	Submergence area at FRL	98 Mm^2

3. Masonry Dam Details

a.	Length of Spillway	218.5 m
b.	No. of Gates	15
c.	Size of Gates	12x6.5 m
d.	Type of Gates	Radial
e.	Design Flood	10480 cumec

4. Control Levels

a.	Lowest Bed Level	401.81 m
b.	Outlet Sill Level	423 m
c.	MDDL	426.16 m
d.	Spillway Crest	434.50 m
e.	FRL	441 m
f.	MWL	442.90 m
g.	Top Bund Level	448 m

5. Irrigation	**LBC**	**RBC**
a. Length of Canals	81 km	177 km
b. Discharge	13 cumec	78.40 cumec
c. GCA	238.51 sq.km	1298.64 sq.km
d. CCA	214.66 sq.km	1168.79 sq.km
e. Irrigation Command Area	193.20 sq.km	1051.91 sq.km
f. Annual Cropped Area	206.72 sq.km	1125.54 sq.km
g. Kharif Crops	Hy. Jowar Paddy Groundnut	Hy. Jowar Paddy Groundnut
h. Rabi Crops	Wheat, Gram	Wheat, Gram
i. Two Season Crops	Cotton Chillies	Cotton Chillies
j. Perennial Crops	Sugarcane	Sugarcane

PHOTOGRAPH OF RESERVOIR

Photo 1: Isapur Dam

Photo 2: Isapur Dam

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