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SEDIMENTATION APPRASIAL FOR KODAR RESERVOIR THROUGH REMOTE SENSING & GIS ANALYSIS IN DISTRICT MAHASAMUND [CG]

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Abstract

Reservoir sedimentation has been common phenomena in Water Resources Engineering projects globally. The excessive higher rate of reservoir sedimentation causes problem in reservoir operation and maintenance for designed life period of hydraulic structure. Kodar reservoir of district Mahasamund [CG] has been selected for reservoir sedimentation study through modern approach along with relevant ground truth and validation of field data.

The Remote Sensing & GIS technique have been adapted as modern approach. The visual cum digital interpretation of IRS LISS III & IV Satellite data of path-row 102/57 has utilized. The temporal satellite data belonging to pre-monsoon and post-monsoon season for two years: October 2007 to October 2009 has revealed the status of reservoir sedimentation. The gross storage and dead storage of Kodar reservoir have been analyzed along with major governing factors. The quantification of reservoir sedimentation has assisted in annual rate determination for overall appraisal of reservoir sedimentation. The biological conservative measures for the area seem to be more appropriate due to ongoing paddy rich cultivation in Kharif and Rabi period, as being the part of 'CG Bowl of Rice' towards the minimizing reservoir sedimentation.

Introduction

Sedimentation over in-land portion is the inter-play among sediment weathering and transportation through wind, water as well as deposition at favorable sites of river regime under overall hydrological cycle. The rate of sedimentation in reservoir has acceleration trend on account of various governing factors like: environmental degradation, temporal land-use change, deforestation, socio-economic set up and lack of appropriate conservative measures. The periodic assessment of reservoir sedimentation has important input for reservoir operation and efficiency of designed life period towards maintenance and improving the Demand-Supply chain of Water Resource.

Modern approach for reservoir sedimentation is based upon the availability of temporal nature of satellite data and GIS tool towards Remote Sensing with supplement through ground truth and validation of field data. It has been applied to area of study for documentation cum appraisal of reservoir sedimentation, as pilot study in C G state.

Area of study

The area of study belongs to Survey of India topo-sheet no. 64K/4 & 64 K/8 with covering geographic area of 307.17 Sq. Km. The Kodar reservoir is located at distance of 65 Km from Raipur, capital of C G state on section Raipur-Sambhalpur of NH 2. It has cluster of hydraulic structure namely: Waste weir, Earthen dam, Left Hand canal, Right Hand Canal, besides Reservoir of gross storage capacity of 160 Million Cubic meter and dead storage capacity of 11.33 Million Cubic meter respectively.

It has been constructed over Kodar river of Mahanadi river system in village Kowaijhar, district Mahasamund. The construction of reservoir has been started in 1976 and completed in 1981 on the name of Shaheed Veer Naraian Singh Bandh.

It has geographic coordinates as latitude N 21°01’ to 21°15’ and Longitude E 82°10’ to 82° 25’. The location map for the area of study is illustrated as Fig. 1.

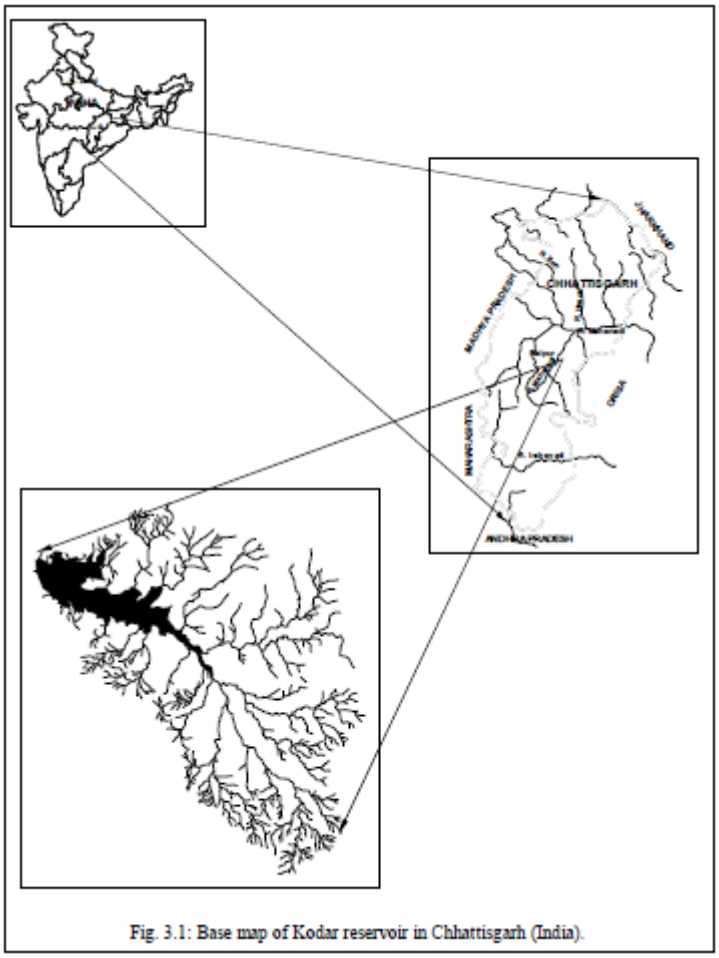

Fig. 3.1: Base map of Kodar reservoir in Chhattisgarh (India).

Fig.1 Location map for Area of Study

Evolved Methodology & Objectives

The evolved methodology is based upon conventional approach as Relevant Literature Review along with scrutiny of PDS-Hydrology project II of CG Government report.

Nine Relevant Literatures have been reviewed for application of Remote Sensing & GIS in reservoir sedimentation and as follows:

The sediment is the product of erosion in upper catchment of reservoir. The finer sediments in suspension stage are deposited in reservoir, and termed as 'Reservoir Sedimentation'. It is governed by rainfall, terrain set up, geology and vegetation cover as basic parameters. The small percentage of total storage capacity for reservoir is left unutilized and termed as 'Dead Storage' [7].

Reservoir sedimentation is natural process- involving erosion, transportation and deposition of sediments through variety of geological agents. It can never be stopped, but may be minimized and managed under reservoir operation. It may be studied through six methodologies namely: Hydrological Survey, Modern Survey, Empirical Formula, Trap Efficiency, Sediment Distribution and Sediment Density [9].

Remote Sensing & GIS technique have been used in surveying and management of natural resources globally. It has been applied also for modeling of soil erosion in upper catchment of U K Rivers [11].

Digital analysis of Land-sat MSS data has been used for water spread area in Ghatprabha reservoir towards of reservoir sedimentation. It is observed the discrepancy of 8.29 % with comparison to actual field survey [5].

The various Remote Sensing technique have been critically examined for determining reservoir surface area extracted from Land-sat MSS near Infra-Red imageries of different scale [0.4-1.1 Micro meter EMR]. The comparison of these techniques with field data could not derived précised accuracy [10].

The estimation of sediment yield through temporal digital analysis of Remote Sensing & GIS technique have provided better information in easier way with comparison to other methodologies towards reservoir operation study [3].

The sediments through snow melt run off have unsorted nature, as glacial activity has maximum transportation capacity with comparison of river water, coastal water and wind. Guru Govind Sagar reservoir of Bhakhara dam has 80% contribution through snow melt run off in Beas river basin [H P]. The reservoir sedimentation study for Guru Govind sagar has been carried out through visual interpretation of temporal Land-sat-1 & Land-sat -2 imageries with monitoring the water spread area [1].

The sediment through high flood prone river in Damodar river basin has been studied for Panchet and Maithon reservoir sedimentation has been carried out through aerial photo interpretation and field checks during seventy decades as Hydrological survey [6].

Remote Sensing & GIS technique has synoptic and repetitive viewing capacity with advantages like: cost effective, easy to use and requirement of lesser time period for monitoring the reservoir sedimentation, with comparison to other remaining methodologies [10].

The objectives of study are as follows:

- ✓ Assessment of Drainage characteristic
- ✓ Assessment of Geomorphic set up.
- ✓ Evaluation of Land-use
- ✓ Status of Reservoir sedimentation
- ✓ Documentation of Biological conservative measures

Result & Discussion

The appraisal of reservoir sedimentation at Kodar reservoir with use of modern approach has been carried through fulfilling the desired objectives as follows on the basis of scrutiny of PDS-Hydrology project II of C G Government report:

- ✓ Assessment of Drainage characteristic

The drainage is one of the leading factors through channel net-work for sedimentation in reservoir. Kodar river is fifth order stream as per Strahler's classification system. The drainage characteristic has been obtained through topo-sheet interpretation of 1:50,000 scale in conjunction with Remote Sensing, ILWIS, GIS as Drainage density [Dd], Channel frequency [cf] and form factor [Rf].

Drainage density is indicative of soil erosion- the prominent feature of reservoir sedimentation. It has unit Km/sq. Km. The range of Dd has observed as 0.87 to 1.6, which infers the high magnitude of soil erosion.

Channel frequency is indicative of number of channel occurrence in unit area. The range of cf has observed as 0.34 to 1.55, which infers the presence of granite outcrop with cross cut by basic dyke.

Form factor is indicative for status of soil conservation measure. It has dimensionless parameter. The range of Rf has observed as 0.03 to 0.15, which infers low priorty for soil conservative measure in the area.

The catchment area and average annual rainfall in the area is observed as 317 Sq. Km and 1433 mm respectively.

The drainage and road-rail network for the area of study is illustrated as Fig.2.

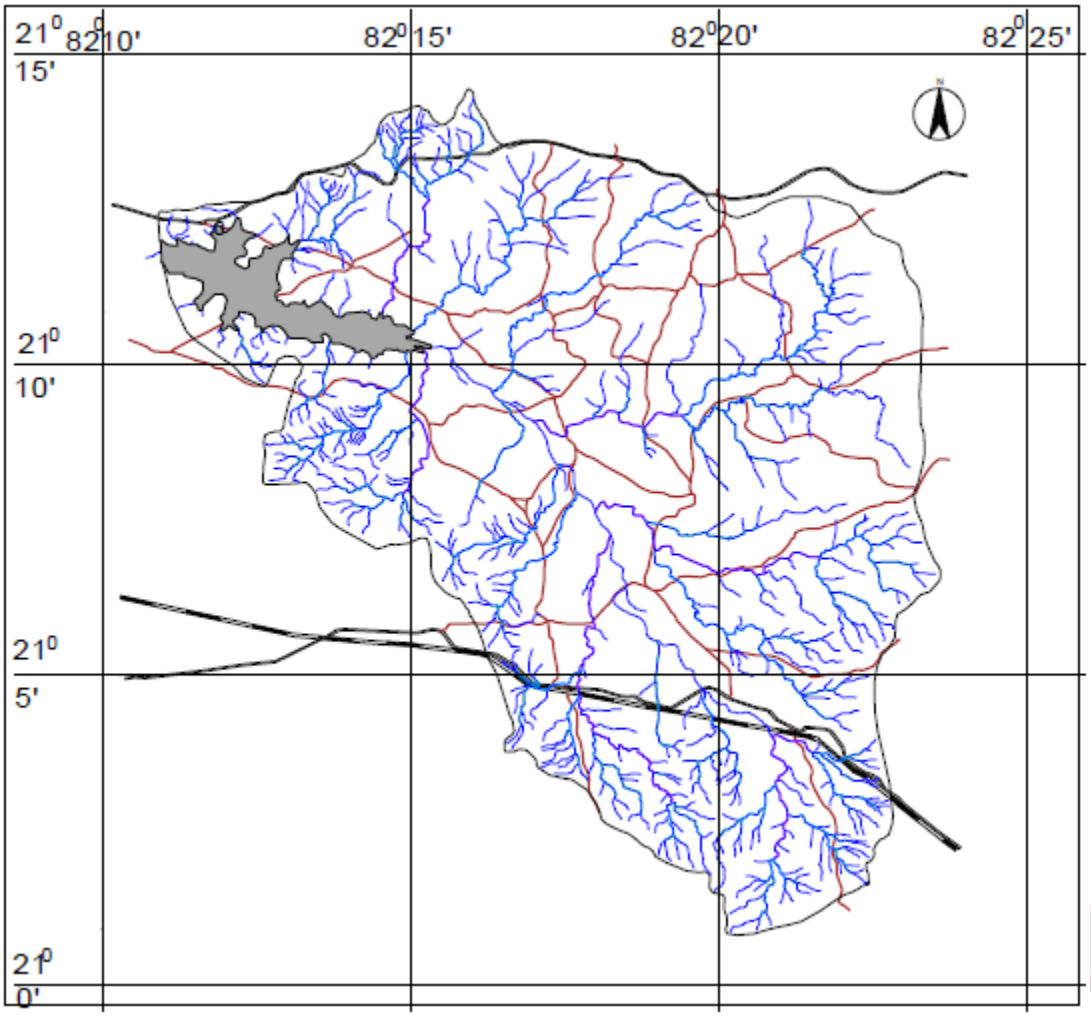

Fig.2 Drainage network for the area of study

✓ Assessment of Geomorphic set up

Geomorphic set up has two major units namely: Piedmont slope and Pedi plain. They are susceptive to higher rate of sediment erosion through wind & water. These features have been evaluated through visual interpretation of LISS III Remotely sensed data on the basis of photo-interpretation identification keys namely: Tone, Texture, Topography and Associated features. The details of geomorphic features have been illustrated as Fig.3. The geographic distribution pattern of these features is summarized as table 1.

S N	Geomorphic unit	Symbol in Fig.3	Geographic area [Sq. Km]	Percentage	Remark
1	Pedi plain Weathered Shallow	PPS	132.16	42.95	Recent alluvium
2	Pedi plain Buried Moderate	PPM	126.16	41.23	Old alluvium
3	Piedmont slope	PD	032.49	10.56	Granitic outcrop
4	Denudated hill	DH	004.29	01.39	Weathered Granite
5	Residual hill	RH	003.75	01.22	Remains of hill
6	Valley fill shallow	VFS	003.68	01.20	Old sediment
7	Inselburg	I	001.79	00.58	
8	Mesa	M	001.45	00.47	Plateau
9	Linear ridge	LR	000.73	00.24	Erosion feature
10	Butte	B	000.49	00.16	
	TOTAL		307.711	100.00	

Table 1: Documentation of prominent terrain features for evaluation of geomorphic set up

The details of geomorphic features along with contour through topography has been utilized for preparation of Digital Elevation Model [DEM] for the area of study and illustrated as Fig.4.

✓ Evaluation of Land-use

The term Land-use /water-use may be explained as “Human imposed function on land/ water portion by living society [2]”. The evaluation of land-use for catchment of Kodar reservoir has been carried out through digital interpretation of IRS LISS IV of October 2009 using supervised classification. The out-put of supervised classification for the area of study has been illustrated as Fig.5. The five categories land-use as obtained has been summarized in Table 2.

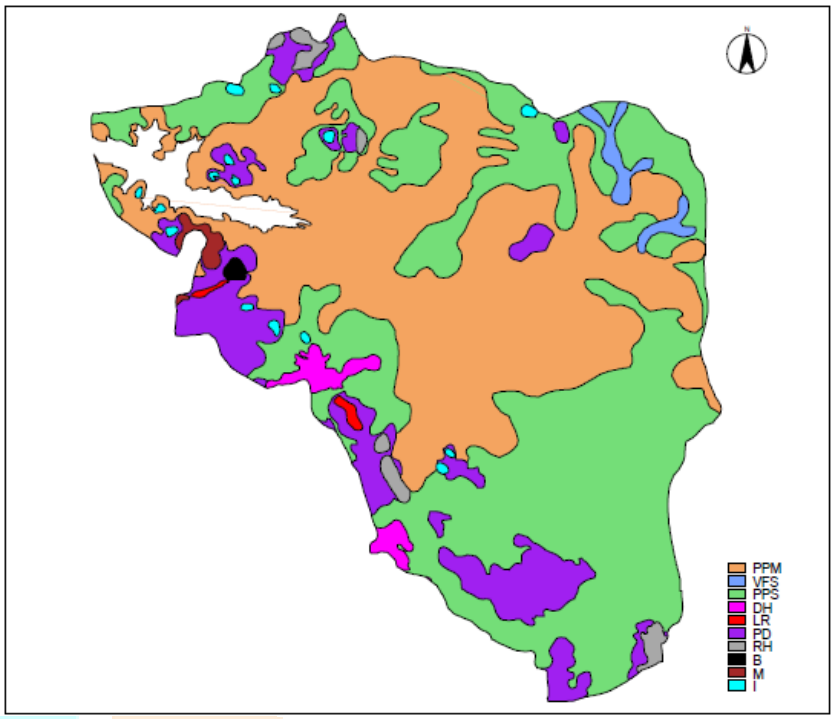

Fig. 3 Geomorphic set up of area

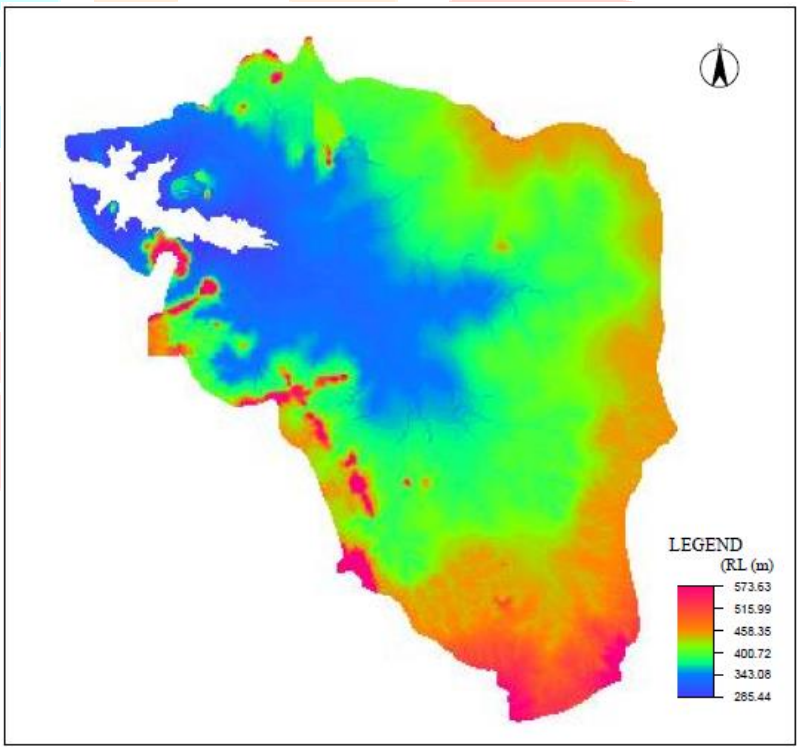

Fig. 4 DEM for area of study

S N	Land-use category	Geographic area [Sq. km]	Percentage
1	Agriculture	243.86	79.39
2	Dense forest	48.38	15.75
3	Settlement	7.88	2.57
4	Surface water body	5.81	1.89
5	Scrub	1.22	0.40
6	Total	307.17	100

Table 2: Different Land-use as observed through supervised classification

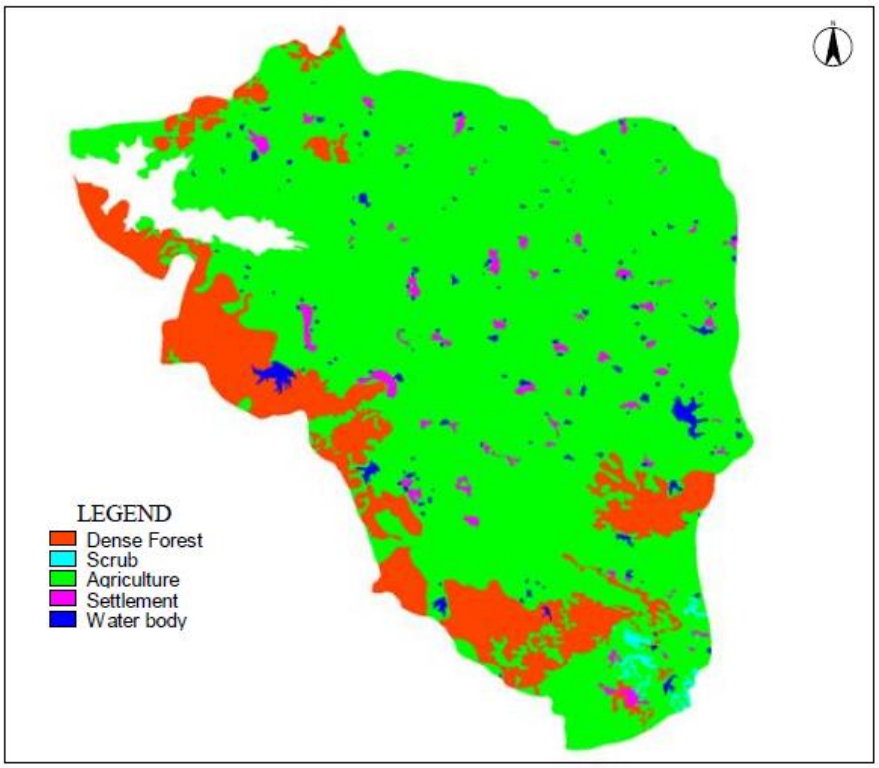

Fig. 5 Land-use through supervised classification for area of study

✓ Status of Reservoir sedimentation

The status of sedimentation in Kodar reservoir has been studied for the period October 2007 to October 2009 through four temporal LISS III satellite data of path & row 102/57 in conjunction with water level as collected through field observation and summarized in Table 3. It covers pre-monsoon and post-monsoon season. The Full Reservoir Level [FRL] of Kadar reservoir is 295.23 m and Dry River Bed of Kodar River is 275.87 m.

S N	Date of IRS LISS III data	Water Level [m] in Kodar reservoir
1	11 October 2007	295.16
2	29 October 2008	289.37
3	09 May 2009	287.39
4	24 October 2009	291.69

Table 3: LISS III data in conjunction with water level in Kodar reservoir

The temporal data has been studied through Standard False Color Composites [FCC] and the comparison of sedimentation in reservoir has been illustrated as Fig.6

✓ Documentation of Biological conservative measures

These are more cost effective, eco-friendly and suitable to CG state. It depends upon terrain set up, geomorphology, drainage, land-use etc. The basic concept is that soil erodes as source of sediment and is effective only, when it is exposed to erosive forces. The major biological conservative measures are: contour farming, boulder bed arrangement, reforestation, and agro-forestry. These features are identified for the area of study on the basis of Remote Sensing & GIS technique and illustrated as Fig.7.

Conclusion

The Remote Sensing & GIS study for Kodar reservoir in conjunction with relevant field checks has concluded the following significant facts for reservoir sedimentation:

- The source for sediments towards reservoir sedimentation is the physical weathering t crop through wind and drainage characteristic of the higher order.
- The mode of occurrence for reservoir sedimentation is favorable along stream transportation on account of low hydraulic gradient of 1:22.

Sedimentation is the integral part of natural hydrological cycle in river regime. When it is disturbed by artificial hydraulic structure [reservoir] it develops the trend for more sediment deposition due to abruption. It is further accelerated on account of variety of human functions

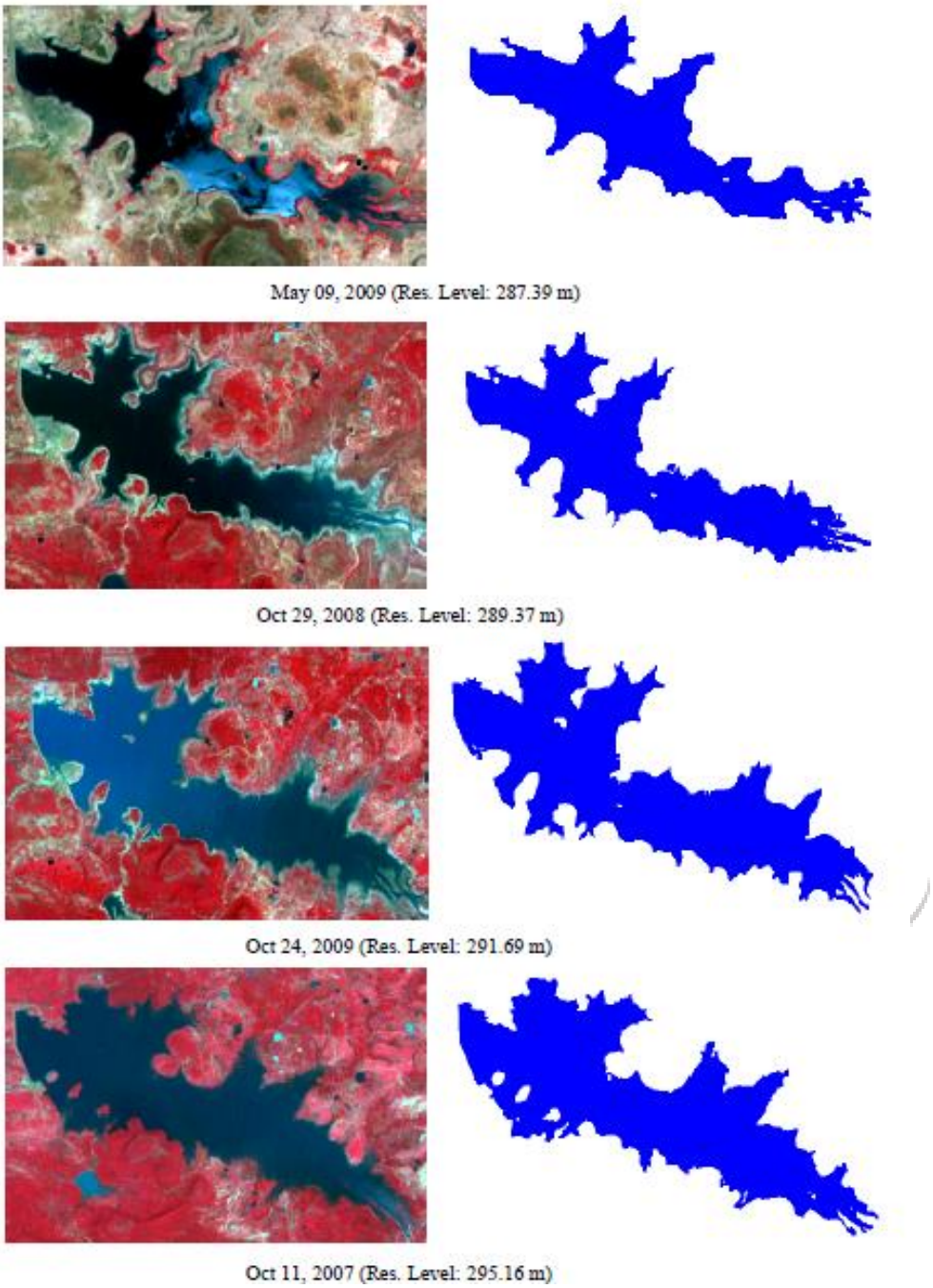

Fig. 6 Status of Reservoir Sedimentation during the period October 2007 to October 2009

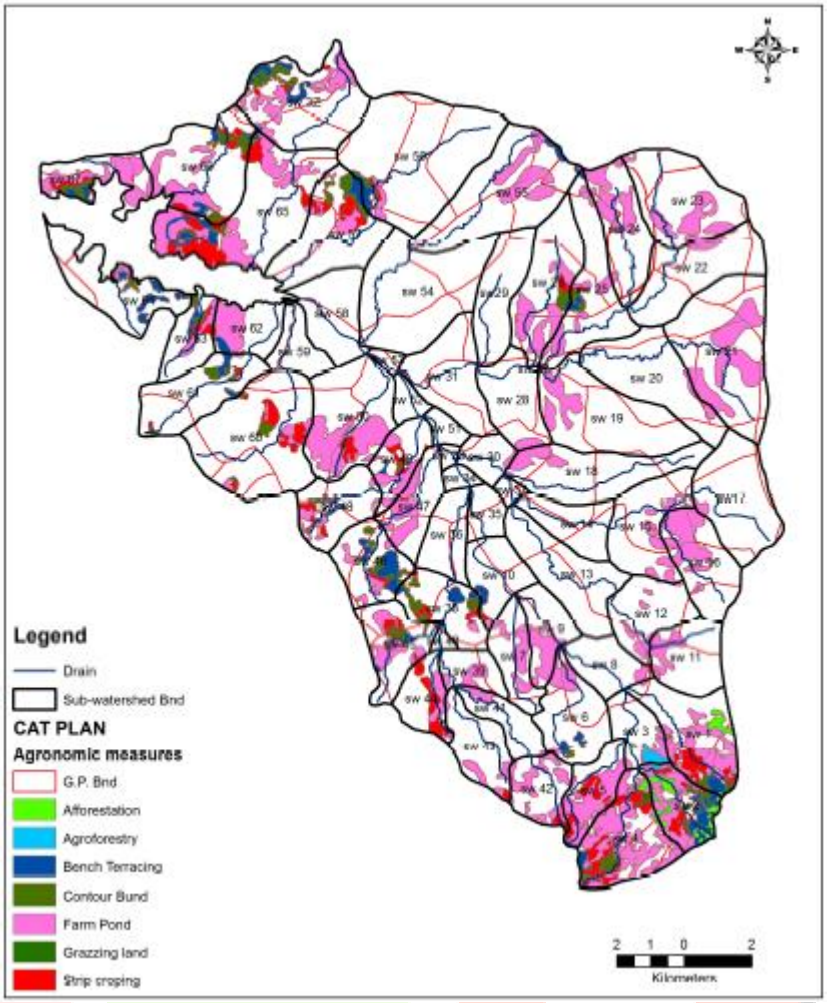

Fig. 7 Biological conservative measures for the area of study

It is evidenced that 24.96 Million cubic meter of gross storage and 4.89 Million cubic meter of dead storage for Kodar reservoir has been lost during the past 32 years [1976-77 to 2008-09]. The similar trend has been documentated in Kansas River basin of USA [3].

- The uniform loss in gross storage and dead storage capacity of reservoir sedimentation has estimated that 0.78 Million Cubic meter of gross storage and 0.15 Million Cubic meter of dead storage have been lost each year with average sedimentation rate of 0.25 Million Cubic meter/100 Sq. Km/ year.
- 80 % of Kodar reservoir has agricultural land with paddy crop during Kharif and Rabi season both, on account of sufficient irrigation facility and sufficient number of surface water bodies. The sediments derived through agricultural activity may be minimized through grazing management, agro-forestry, forestation, reforestation as biological conservative measures.

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