GEO-ENVIRONMENTAL FACTORS FOR ASSESSING SEDIMENTATION - A CASE STUDY OF THATIPUDI RESERVOIR, VIZIANAGARAM, ANDHRA PRADESH, INDIA

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Abstract

Water is one of the essential natural resources without water which we cannot exist on the earth surface. Thatipudi reservoir was constructed across river Ghosthani in year 1968 for storage of water used for drinking and irrigation purposes. The field survey carried on month of Feb 2014 and past data (of inflow, outflow and capacity of reservoir) collected from irrigation engineering department. Geo-environment factors like rainfall, temperature, topography, rock type and process of weathering in upstream area are causes for deposition of sediment in the reservoir and its effect on storage capacity of water were discussed. This is confirmed by using prismoidal formula, land use and land cover analysis by Arc GIS and ERDAS.

Keywords: *Geo-Environmental, Sedimentation, Prismoidal, Remote Sensing and Gis*

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1. INTRODUCTION

Thatipudi reservoir was constructed across river Ghosthani at Thatipudi village, Gantiyada mandalam, Vizianagaram district lies between lat. North 18^0 16` 99`` and long. $83^0$ 19` 75``. The gross storage capacity is 94.164 MCM and live storage capacity is 88.04 MCM. The irrigation ayacut of 15.378 acres and supplied drinking water supply to Visakhapatnam and Vizianagaram cities the need of increase of drinking water with increasing population in both the cities. In view of this, the effect of storage capacity of water due to sedimentation by geo-environmental factors are studied and correlated by Arc GIS.

2. DATA COLLECTION

- Water depths at various locations in the reservoir were measured to compute the amount of sediment upto year 2014 using mathematical formula.
- Data was collected from irrigation department which constitutes of details related to precipitation, inflow, outflow, capacity of reservoir for the past 30 years i.e., from 1980-2013.
- Area elevation curves of Thatipudi reservoir was also collected.
- Satellite images from National Remote Sensing Centre (NRSC) and earth explorer were also taken for land use and land cover analysis. The dates for which the satellite images were classified are:
- From Earth Explorer website-In the year 1973,October, year 1975 December, year 1977 February
- From NRSC-In the year 1988, October, year 1990, February
- From Bhuvan -In the year 2009, October, year 2011, December
- Few images which were taken from NRSC could'nt be used for the purpose of classification due to certain problems and hence are not mentioned here.

3. METHODOLOGY

The depth of water column in various locations in the reservoir area was measured to compute the amount of sediment upto year 2014. The past data from 1980-2013 was obtained from the concern engineering department. The average value of depth of water column was taken and depth of sedimentation on the bottom of reservoir bed was calculated with respect to bed level. Using the satellite imageries the observed the vegetation, rainfall and weathering process in upstream area of the reservoir.

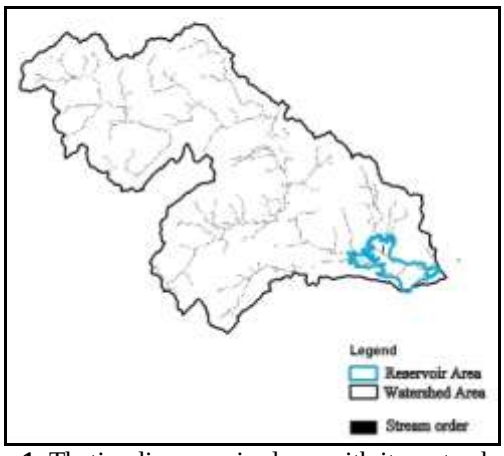

Figure 1. Thatipudi reservoir along with its watershed and drainage patter

3.1. Geology

A close study of the ghat section at various altitudes on the Ananthagiri hill ranges revealed the interrelationship among the garnetiferrous-sillimanite-gneiss and schists, basic, intermediate and acidic charnoekites, quartz-diopside granulites, garnetiferrous quartzites, calc-silicates, granite gneisses, pegmatite veins and migmatites. The khondalite and charnockite group of rocks occur by and large, as conformable bands with a regional NE-SW trend and moderate to steep (50^o to 85^o) south easternly dips, strike and dip joints are prominent synformal hills and antiformal valleys are common in the eastern terrain Ramam(1976). The average annual rainfall is around 900mm. it varies from 662.70mm & 1204mm in the year 1983 and 2014 respectively (Figure 3).

The Patal and Ghosthami Rivers drain the Ananthagiri area. A number of pernnial and seasonal streams added to the drainage density of the area. The temperature varies from 16^o to 24^o on hill peaks and 24^o to 40^o below the 600mts altitudes and on the plains. The climate conditions on the hill peaks and on the plains is extremely different. Humid megathermal climate prevails on the hill peaks and while semi-arid on the plains.

3.2. Weathering Process

The role of environmental factors as rocktype, topography and climate on weathering has been evaluated. The weathering of khondalites and charnockites at higher altitudes attributed micro-level environmental conditions i.e. alkaline pH and low silica content in the altering mineral face. Topography is considered to influence only drainage conditions, good drainage conditions exit over the entire hilly terrain, relatively poor drainage conditions on the plains climate is inferred to play a very significant role on weathering. High rainfall aided by undulating topography at higher altitudes facilitates intensive drainage and erosion of soil. Low temperature and high humidity provide continuous moisture in the weathering front, promoting active chemical reaction through out the year and it is opposite below 600mts. Relatively low rainfall, alter rate wet and dry spells and semi-arid nature at lower altitudes (Suryanarayana et al 1983). It is evident that weathering is more on higher altitudes and more erosion of soil when heavy rainfall in 1990, 2009, 2011 etc., and confirmed the rate of sedimentation more in respective years in the reservoir. The Figures from Figure 4 to Figure 10 and Table 2 shows vegetation (deforestation) is less and it causes to more erosion of soil. Basing on the field survey the amount sediment deposited Table1 assessed by prismoidal formula is found to be 51.84 MCFT. The figure 11 and Table 2 shows above for various classes depicting the areal spread clearly that major part of the watershed is vegetation. The years 1988 and 1990 there was sudden change in vegetation cover which might be due to deforestation. The area under agricultural increased tremendously in those years.

In the Figure 12 and Figure 13 shows the sediment analysis by DEM by the top view and side view of the Thatipudi reservoir but the Figure 14 shows the reservoir along with the sediment plane which obtained from the field survey sediment depth values. The Figure 15 shows the side view of the same. The estimated sediment volume is found to be 63MCFT by 2014.

4. RESULTS AND DISCUSSIONS

In this paper the estimated values of sediment deposited determined using prismoidal formula are tabulated and graph is plotted. Besides land use and land cover analysis done using ERDAS and results are also enlisted. Drainage pattern developed using Arc GIS are also displayed. As per the results obtained from assessment of sediment from prismoidal formula and that of land use and land cover analysis certain possible conclusion can be drawn.

Finally concluded that the amount of sediment deposited estimated by prismoidal formal is 51.84mcft. Basing on rainfall data shows a deviation in the year 1988 and 1990. The value is very high compared to other years. This can be confirmed to the land use and land cover analysis Arc GIS and also the vegetation area suddenly reduced which might be the cause for increase of sediment deposition in the reservoir.

4.1. Estimation of Volume of Sediment Based on Field Survey

Basing on the field survey the amount of sediment deposited assessed using prismoidal formula is found to be 51.84 MCFT.

Table 1. Estimation of volume of sediment based on field survey

Year	Annual rainfall (mm)	Weighted average	Yearly sediment deposition (MMCF)	Cumulative sediment deposition (MMCF)
1983	662.70	0.022247	1.153	1.153
1984	543.90	0.018259	0.946	2.099
1985	712.30	0.023913	1.239	3.339
1986	906.90	0.030445	1.578	4.917
1987	721.60	0.024225	1.255	6.173
1988	713.70	0.02396	1.242	7.415
1989	745.60	0.02503	1.297	8.713
1990	2095.00	0.070331	3.645	12.359
1991	522.40	0.017537	0.909	13.268
1992	580.00	0.019471	1.009	14.277
1993	404.00	0.013563	0.703	14.980
1994	564.00	0.018934	0.981	15.962
1995	791.00	0.026555	1.376	17.338
1996	704.00	0.023634	1.225	18.564
1997	657.30	0.022066	1.143	19.707
1998	1044.90	0.035078	1.818	21.526
1999	778.70	0.026142	1.355	22.881

2000	966.50	0.032446	1.682	24.563
2001	954.00	0.032027	1.660	26.223
2002	664.00	0.022291	1.155	27.379
2003	797.00	0.026756	1.387	28.766
2004	854.90	0.028700	1.487	30.254
2005	1483.75	0.049811	2.582	32.836
2006	1119.40	0.037579	1.948	34.784
2007	1354.70	0.045478	2.357	37.142
2008	950.50	0.031909	1.654	38.796
2009	1217.50	0.040873	2.118	40.915
2010	1647.90	0.055321	2.867	43.783
2011	1017.60	0.034162	1.771	45.553
2012	1204.00	0.040419	2.095	47.649
2013	1204.00	0.040419	2.095	49.744
2014	1204.00	0.040419	2.095	51.840

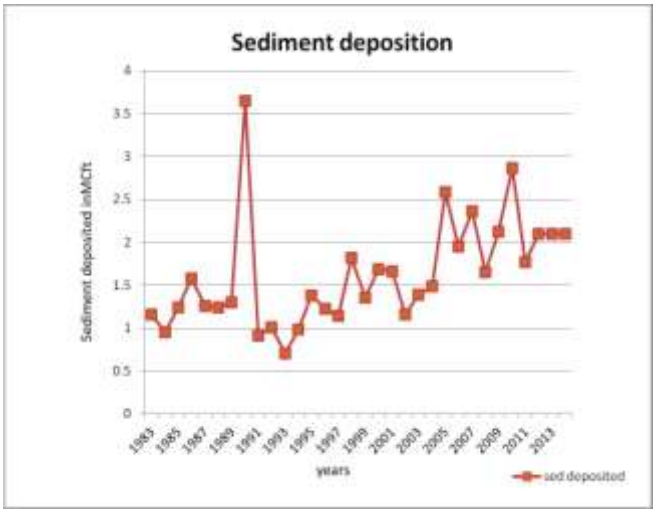

Figure 2. Graph showing sediment deposition versus years

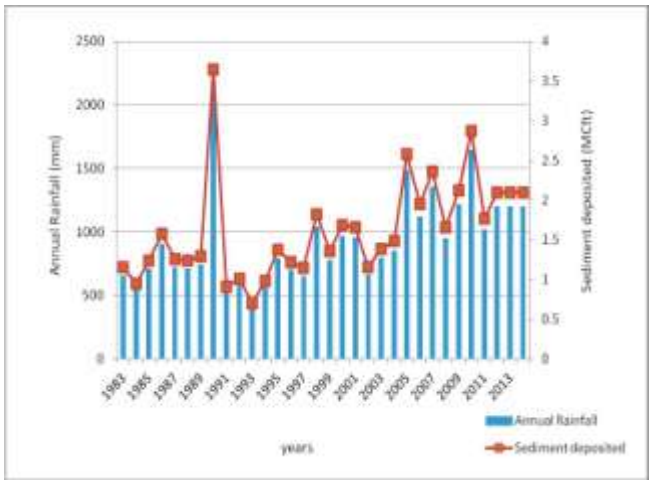

Figure 3. Graph showing sediment deposition and annual rainfall v/s years

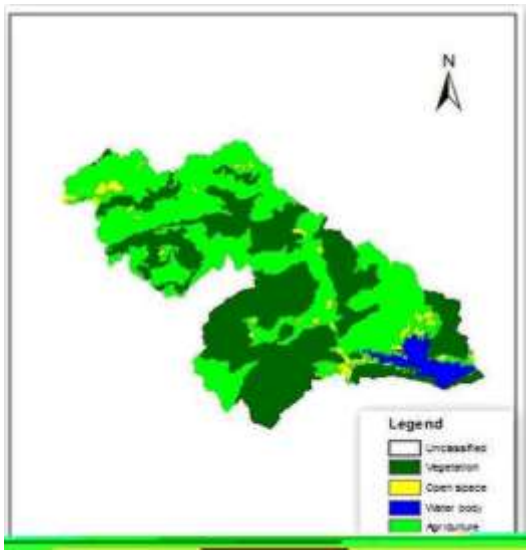

Figure 4. Classified image of 1973

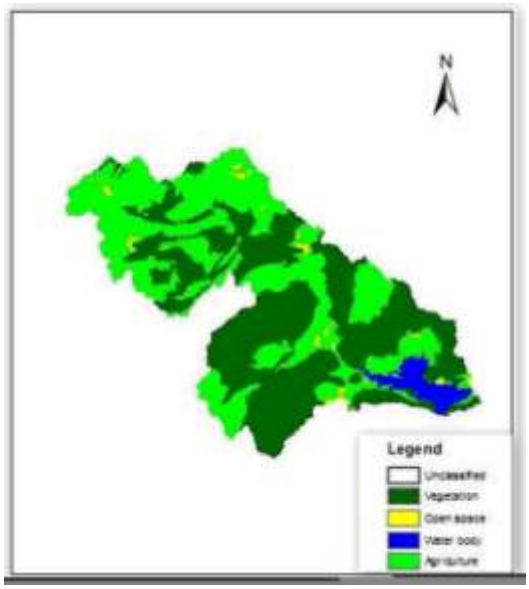

Figure 5. Classified image of 1975

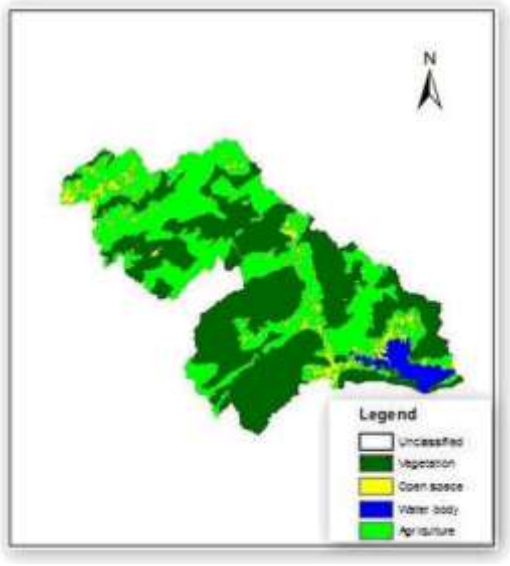

Figure 6. Classified image of 1977

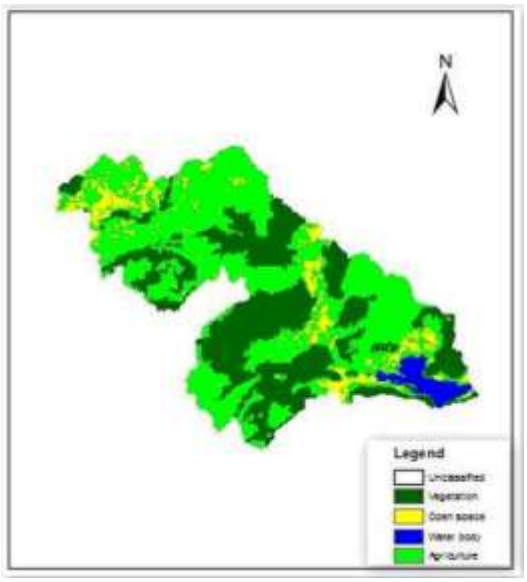

Figure 7. Classified image of 1988

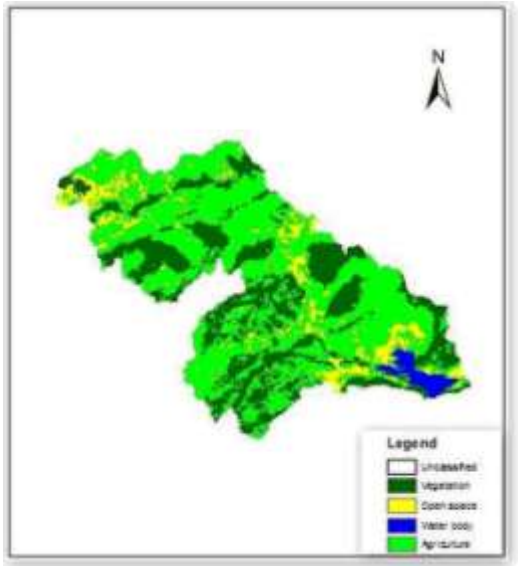

Figure 8. Classified image of 1990

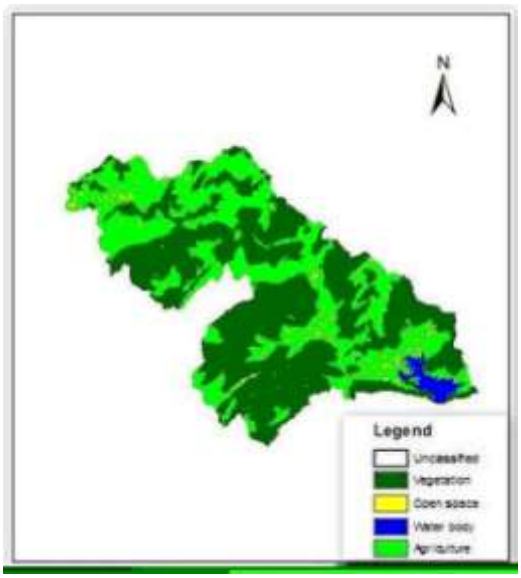

Figure 9. Classified image of 2009

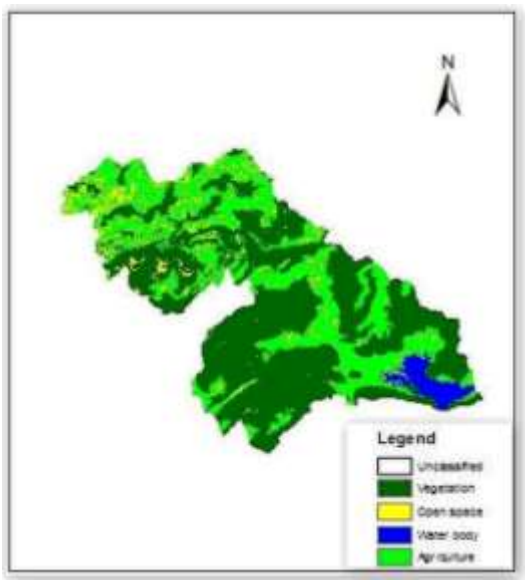

Figure 10. Classified image of 2011

Table 2. Comparizon of percentage area of each class

Year	Vegetation (sq km)	Open space (sq km)	Water body (sq km)	Agriculture (sq km)
1973	46.35	2.84	3.34	47.74
1975	50.69	14.12	3.76	44.13
1977	50.96	5.45	3.27	40.32
1988	36.02	8.4	3.02	52.56
1990	30.4	10.82	2.32	56.46
2009	56.4	3.09	1.98	38.53
2011	56.49	7.52	3.13	32.86

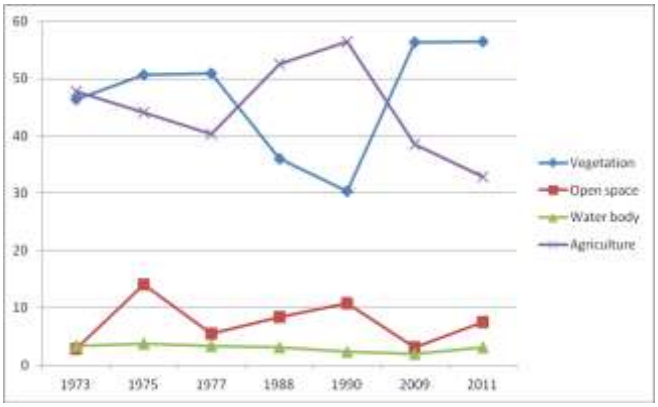

Figure 11. Percentage area under each class versus years

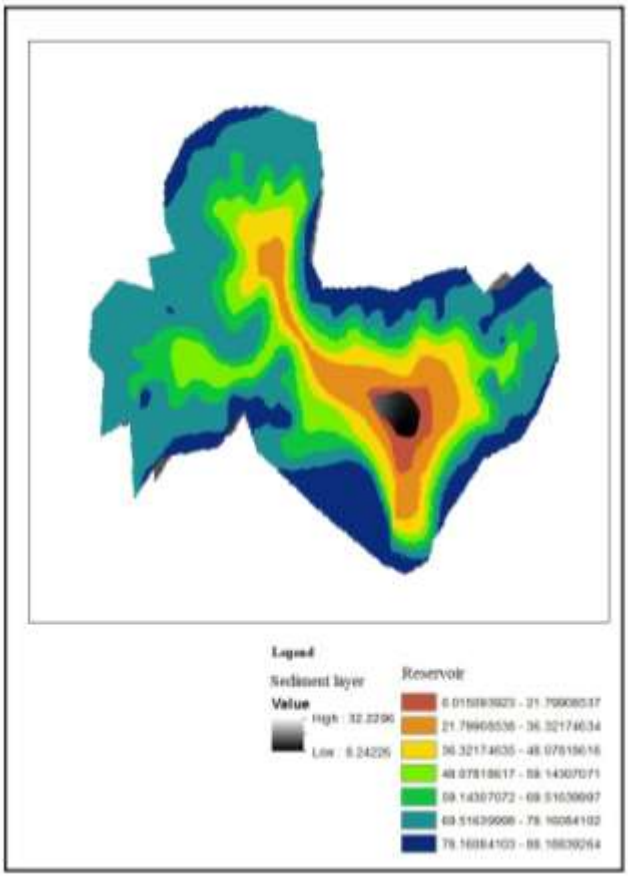

Figure 12. Reservoir top area

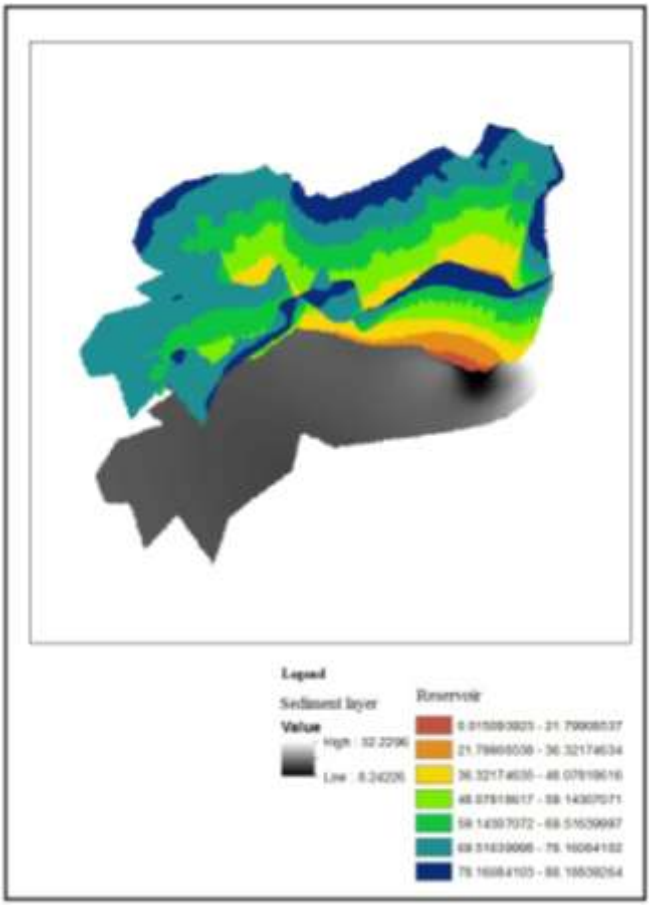

Figure 14. Reservoir with sediment plane 1

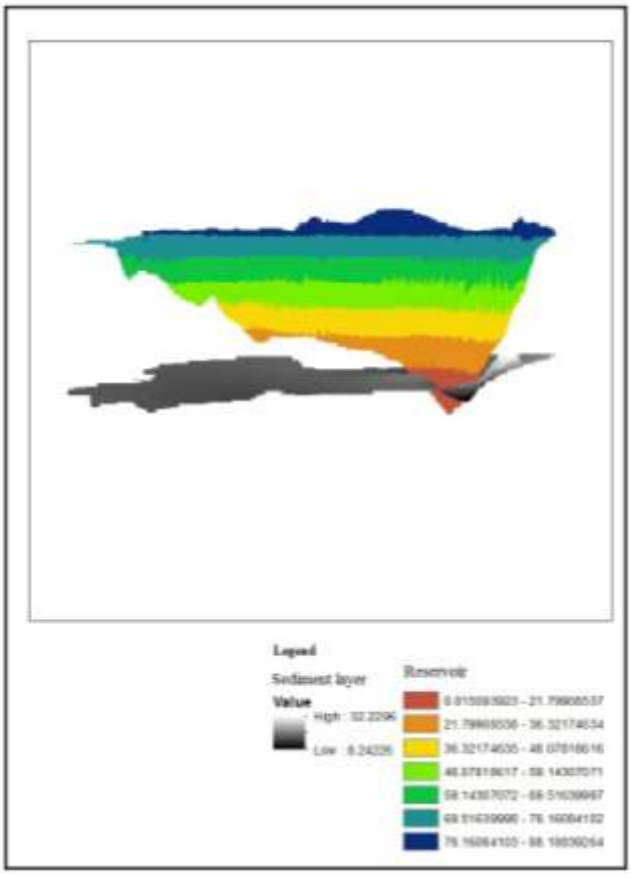

Figure 13. Side view of reservoir

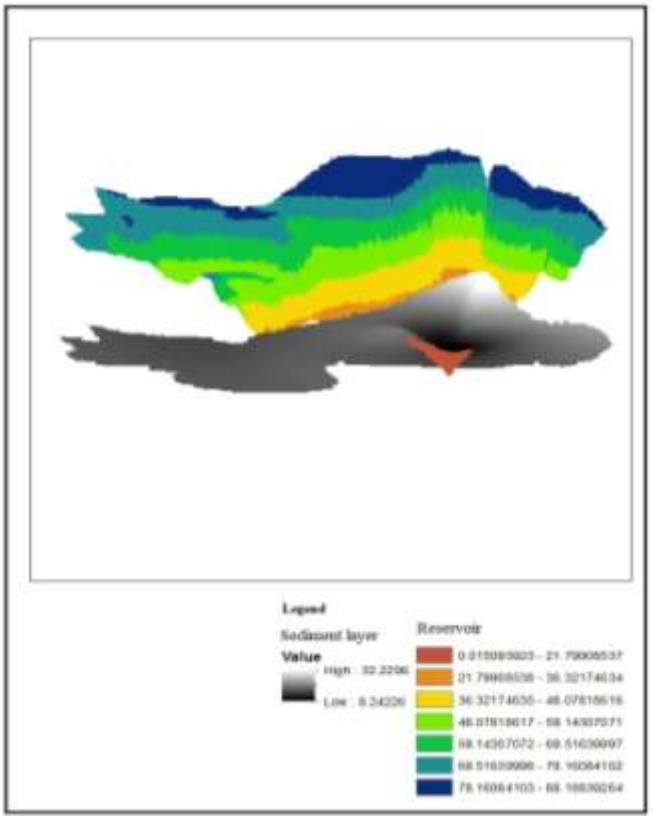

Figure 15. Reservoir with sediment plane 2

In the Figure 12 and Figure 13 the top view, contours and side view of the Thatipudi reservoir are shown respectively. The Figure 14 shows the reservoir along with the sediment plane which is obtained from the field survey sediment depth values. The Figure 15 shows the same in side view.The estimated sediment volume is found to be 63MCFT by 2014.

5. CONCLUSIONS

The elements of environmental factors rocktype, topography, climate and rainfall are the main casues of erosion of soil in the year 1988, 1990 and 2009 are confirmed more rate of deposition of sediment in the reservoir. It as clearly confirmed by GIS analysis.

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