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Application of Geo- Spatial technologies for Integrated Watershed Management of Meghadrigedda Reservoir, Visakhapatnam District, A.P, India.

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Abstract: Watershed management higher cognitive process is a complex process. Cooperation and communication among federal, state, and native stakeholders is required while balancing biophysical, socioecological and socioeconomic concerns. The general public is collaborating in environmental decisions, and also the need for technology transfer from public agencies to stakeholders is increasing. Information technology has extreme influence on watershed management over the last decade. Advances in data acquisition with remote sensing, utilization of knowledge through geographic information systems (GIS) and sharing the data through the web provided watershed managers access to more information for management decisions.

Using Satellite imageries of years1976, 2005, 2011 and 2015, change detection was done. By using the SCS - CN curve method, the surface runoff calculation was done and ERDAS and ArcGIS software's were used for integrating and mapping of satellite data. The results include change detection map, Catchment boundary, Drainage patterns and Soil group's maps of the watershed for visualization of topographic characteristics of the watershed as tools for informed higher cognitive process by managers during conservation and management process. Digitized data on soil, land use, topography and surface drainage pattern are overplayed using Arclnfo GIS. Remote Sensing and Geospatial Information Systems (GIS) techniques, and their ability to capture, manipulate, exhibited data store, have found great benefits within the analyses of any spatial phenomena with speed and accuracy anywhere on above &below the earth surface. One such application is watershed conservation and management. Generally water quality assessment and monitoring techniques are time, data and consequently capital intensive - often beyond the means of developing nations. Utilizing the geospatial capacity of RS and GIS approaches provides an economical and research quality solution to those issues of waternomics.

Index Terms - Watershed Management, Land use & Land cover, GIS& Remote sensing, ERDAS & Arc GIS, SCS – CN Method, Waternomics etc..,

1. Introduction:-

Water is life, altogether forms and shapes. It is very important natural resource, crucial for the survival of all living things (Javarayigowda, Basavaraju & Jayaram, 2018; Kiran & Srivastava, 2014; Tejaswini & Sathian, 2018). Availability of Water is currently decreasing with an increasing demand, due to increasing population, human consumption, agriculture, industry, and livestock needs (Kiran & Srivastava, 2014). Water is a vital nutrient and plays a key role within the body. We are able to survive up to many weeks without food, but only some days without water. Water allows the body to absorb and assimilate minerals, vitamins, amino acids, glucose and other substances. Water flushes out toxins and waste, Water exists in several forms like rainfall, river water, water in ponds and lakes etc.

About 71 percent, surface of the Earth is covered with water, and also the oceans hold about 96.5 percent of all Earth's water. The majority of water on the surface, over 96 percent, is saline water within the oceans. India has had abundant supply of water resources. Traditional irrigation water bodies are commonly situated in many parts of Indian sub-continent to arrest monsoon runoff. India having many water resources, now due to population pressure, urbanization, scarcity of water is imminent. Water is becoming scarcer and each forewarning alert indicates that it'll become even more critical within the future. With socio-economic development, contradiction becomes conspicuous between necessitate for water and its limited resources, and it's a matter of concern to the watershed community, like water resource researchers, scientists and policy makers. The need of the hour is sustainable management of watersheds or water catchment area. Hence, it becomes important to use the emerging tools and technologies for ubiquitous watershed management.

Population explosion in rural areas tempered with lack of knowledge on agricultural 'good practices' implies unsustainable use of water, more land degradation, higher poverty levels and health problems. This scenario demands for economical management of accessible resources, both natural and man-made, especially watersheds and wetlands. This will only be achieved by employing the correct technology. Diversity in physical landscape leads to different classes of land, which are subjected to differing types of utilization/land use to the most extent possible because of increasing pressure onto land, for agricultural pursuits by the ever increasing population especially in rural areas. This has resulted in uncontrolled exploitation of resources leading to unproductive or degraded land. Such degraded lands, which are currently underutilized, are continuously deteriorating due to lack of water and appropriate soil management practices or on account of natural cause are called Wastelands. Watershed management decision making is inherently complex. Watershed management decisions are further complicated by both the complexity of the problems and the people's processes creating the issues. It requires cooperation with federal, state, and native bodies while incorporating biophysical, socioecological and socioeconomic process. Traditionally, transfer of knowledge was unidirectional, typically from state of central agencies to landowners. In today's society, bidirectional communication is important, expanding the role of land management agencies within the higher cognitive process.

The ability of Geospatial Information Systems (GIS) and Remote Sensing technologies in data capture, storage, analysis/querying and displaying has proved to be fast, accurate and cheap thus useful tools for environmental conservation and management (Chang, 2009). A watershed is defined as natural Hydrologic entity that covers a particular area of land surface from which rainfall runoff flows to an outlined drain, channel, stream or river at any point (UNEP, 1990)". Watersheds are hydrologic units considered to be efficient and appropriate for the assessment of accessible resources within a neighborhood thus influencing subsequent planning and implementation of assorted development programs within that area. Hence, all the fundamental natural resources within a watershed like soil, water and vegetation within the hydrological entity of a watershed area should be managed sustainably.

Role of Geographic Information System (GIS) in Watershed Management

Remote sensing is the non-contact recording of information from various electro-magnetic spectrum regions by means of instruments such as cameras, scanners, lasers, linear arrays and/or area arrays located on the ground or aerial platforms (Jensen 2007) and the analysis of the acquired information by means of visual and digital image processing (Sabins 1987).

Geographical Information System (GIS) can be defined as a system, which facilitates the storage and intelligent use of geographic data and human activities (Srivastava 2003). The essential features of GIS are the use of sophisticated computer hardware and software to collect, store, manipulate and process for geographic data (Singh 2010). GIS is a tool that allow for the processing of spatial data into information (Samarakoon 2005).

GIS and Remote Sensing technologies offers technologically suitable method for land resource assessment, delineating different land use patterns, flood management, irrigation water management, assessment and monitoring of environmental impact of watershed projects. It is also useful in delineating hydro-morphological units in the area to decide suitable sites for land and water harvesting structures in the problematic sites.

2. Previous related works:-

Surface water bodies are dynamic in nature as they shrink, expand, or change their appearance or course of flow with time, due to different natural and human-induced factors (Karpatne et al., 2016). Variations in water bodies impact other natural resources and human assets and further influence the environment. Change in surface water volume usually causes serious consequences. In extreme cases, rapid increase of surface water may end up in flooding. Therefore, it's crucial to efficiently detect the existence of surface water, to extract its extent, to quantify its volume, and to watch its dynamics.

P.Malleswara Rao et.al (2011) has studied a case study on Hydrological problems of Mudasarlova Reservoir, Visakhapatnam city. Annual yield, Monsoon yield and dependable yield was calculated from SCS – CN Method, maximum rate of runoff was calculated using four methods. The average rainfall was computed from the average annual rainfall of Visakhapatnam and Pendurthi Rain gauge stations by Thiessen Polygon Method.

G. Sreenivasuluetal (2013) made an analysis on Land Use/Land Cover Using Remote Sensing and GIS in and around Vempalli, Kadapa District, and Andhra Pradesh. Under the study three thematic maps such as location map, drainage map and land use / land cover maps were prepared. The land use and land cover analysis on the study area was attempted based on thematic mapping of the area consisting of built-up land, cultivated land, water bodies, forest and uncultivated land using the satellite image.

Usha Chiralaetal (2015) study aimed at identification and mapping of erosion prone zones with respect to silt deposition using remote sensing and GIS techniques of Meghadrigedda Catchment. The study has noticed that various forms of erosion like sheet, gully and stream erosion are responsible for the siltation at large scale which is causing reduction of its designed storage capacity by 40%. Siltation was identified as the major problem in Meghadrigedda reservoir which is gradually reducing its holding capacity year after year and also affecting the water supply system connected to it. Soil conservation measures included social forestry was suggested. The remaining areas in the catchment are recommended with measures such as, checking dam construction, silting traps, contouring bunding.

Kiran Jalem (2016) studied development of water resources for micro watershed at Chinnamusidiwada village in Visakhapatnam, Andhra Pradesh, India. The work examined the three existing tanks and carried out using both spatial technology and ground based observations. Total Station survey was carried out for the tanks. Geophysical explorations were also carried out, which identified the thicknesses of top soil, weathered rock, fractured rock, hard fractured rock and hard rock formations, to assess the volume of the groundwater that can be stored in the aquifer system. Change detection analysis was carried out and witnessed remarkable expansion, growth and developmental activities such as building, road construction and many other anthropogenic activities and resulted in increased land consumption, modification and alterations of land use/cover over time without any detailed and comprehensive attempt.

M.Rjasekharetal (2017) has worked on the spatio-temporal dynamics of Land use/cover of Uravakonda, Anantapur District, by using Remote Sensing and GIS. The images of the area were categorized into five exceptional classes, specifically vegetation, agriculture, barren, built-up and water body. The study revealed that the major land use in the study area was barren/waste land and increased by eight percent, agriculture which was decreased by 6.4% (25.5 sq.km) due to adaptation in vegetation, barren land and built-up land and water bodies area also have decreased. The built-up land has been increased by 3.5% due to alteration into urbanization and industrial areas.

Madhuri Mulpuru et.al, (2019) has carried out Land Use/Cover change detection analysis for Thandava Reservoir Catchment of Visakhapatnam using Geo-Spatial technologies. In the analysis, both digital and visual interpretations of land use/land cover have carried out. The land use/land cover categories delineated from the study area categorized as Built-up land, Deciduous Forest, Degraded forest, Water body, Reservoir, Agriculture land, Dry land and other, Plantations, Barren rocky land. Land use/cover change detection for the years 2000 and 2011 were studied to project the extent and severity of deforestation in the reservoir catchment.

Rudresh Sugam etal (2018) carried a research study in Meerut district to in identifying status of traditional water bodies and suggested steps necessary for protection of the water bodies using ground survey using GPS, GIS mapping & water quality testing of hundred twenty ponds in the district.

P.Jagadeeswara Rao et.al.,(2006) Studied silt deposition in Gambhiram Reservoir by Remote Sensing Approach. The themes slope, geology, drainage, land use / land cover and geomorphology from satellite data played an important role in the determination of Silt Yield Index. The Silt Yield Index (SYI) technique was used to assess the effects of silt on the storage capacity of the reservoir. The study was conducted at watershed level to understand the fluviatile activity of the river system. The study area is divided into 7 micro watersheds on the basis of drainage conditions. The micro watersheds 5 and 6 adjacent to the reservoir have rolling topography with moderate slopes contributing more silt to the reservoir.

3. Study Area:-

Visakhapatnam is named as executive capital and the largest city of the Indian state of Andhra Pradesh. The District has a population of 42.88 lakhs (Census 2011) and present population of the district is 46.94 lakhs (2021 estimated).Visakhapatnam city is located on the East coast of India with geographical co-ordinates $17^{O}15'$ & $18^{O}32'$ Northern Latitude, $18^{O}54'$ & $83^{O}30'$Eastern longitudes. It is the third largest city in the East coast of India after Chennai and Kolkata and the fourth largest city in South India and witnessing a rapid expansion of residential and other built – up areas in both horizontal and vertical expanses.

I. Meghadrigedda Reservoir:-

Meghadrigedda Reservoir is located in the Village limits of Narava (Village) Pendurthi (Mandal) of Visakhapatnam District. The Project is intended to supply water for drinking purpose to Greater Visakhapatnam Municipal Corporation (GVMC), and also to cater the needs of Industries in and around Visakhapatnam at the rate of 8MGD. The construction of project was completed during 1977 at the total estimated cost of Rs. 6.30 Crores. It is one of the main water sources for the entire Visakhapatnam city. It was maintained by Greater Visakhapatnam Municipal Corporation, is the only major reservoir close to the city. A major portion of it is earmarked for industrial supply.

Meghadrigedda watershed, a significant drainage basin forming a reservoir in the central portion, towards downward and bounded with arcuate hill ranges ranging from 70 to 594 m above Mean Sea Level. The watershed is irregular in shape with a maximum length and width at places 25 by 25 km^2, N-S trending system of small streams and water tanks. The watershed drained from variety of agricultural fields, forests and rainfall from near hilltops. The utility of water from this reservoir is used for Industrial purposes and major source for the water supply to the Visakhapatnam city (PWD report, 1977).

II. Location:-

Meghadrigedda Reservoir is located between Narava and Yerrakonda hills in vicinity of Visakhapatnam district.
Location:- Narava (V) Pendurthi (M)
Longitude: 83° 11' 27"
Latitude: 17° 45' 54"
Dead Storage: 1267 Mcft
Live Storage: 1043 Mcft
Gross Storage: 1169 Mcft
F.R.L: 61 ft
M.W.L: 63 ft **T.B.L:** 71 ft
Catchment Area: 366.48 Sq.Km
Max. Flood Discharge: 53000 Cusecs

III. Utility:-

The project is intended to supply water for drinking purpose through Greater Visakhapatnam Municipal Corporation and also to cater the needs of Industries around Visakhapatnam at the rate of 8MGD.

Villages Benefitted: 72

Mandals Benefited: Visakhapatnam,Gajuwaka, Pendurthi & Sabbavaram

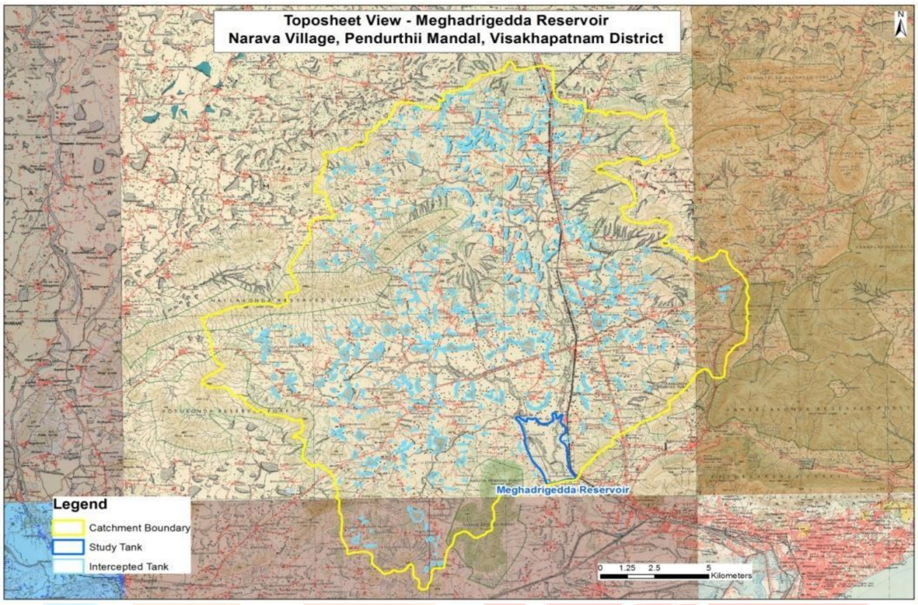
Cropping Pattern: Nil

Ayacut: Nil

Utilization: 8 MGD

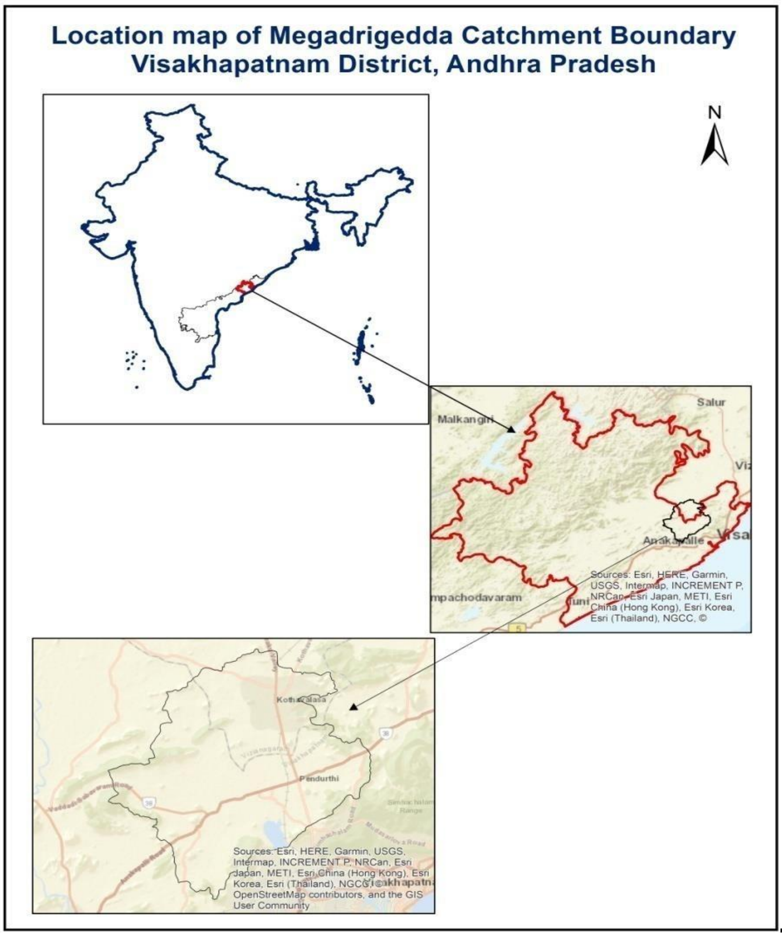
Map 1:- Below map shows the Location map of MeghadrigeddaCatchment Boundary Visakhapatnam District, Andhra Pradesh, India

Map 2:- Below map shows the Toposheet view of Meghadrigedda Reservoir, Narava Village, Pendurthi Mandal, andVisakhapatnam District

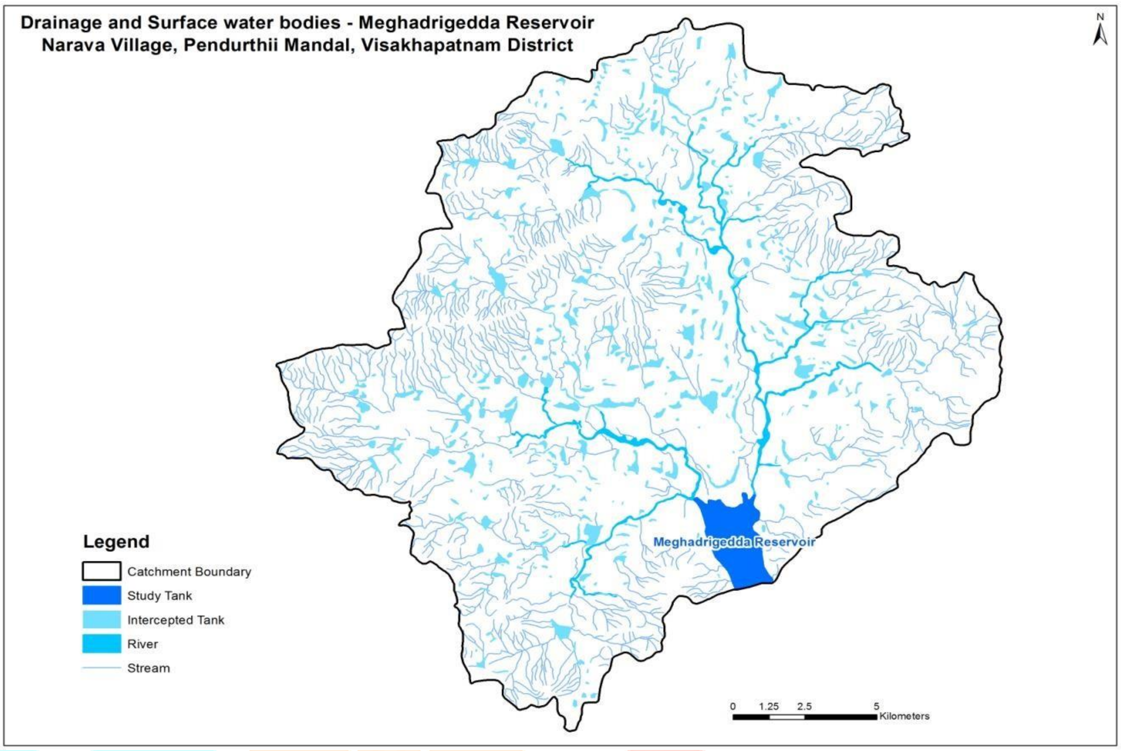


IV. Drainage and Surface Water Bodies:-

Meghadrigedda Reservoir is a major reservoir that supplies drinking water to Visakhapatnam city, Gajuwaka, Pendurthi & Sabbavaram Mandals. The feeding source for this reservoir is from the Borrammagedda and Naravagedda. The topography of the reservoir catchment is characterized by hills, valleys and plains. In the catchment area of the tank, rivers and drains are from the contours and hill stations.



Map 3:- Below map shows the Drainage and Surface Water bodies - Meghadrigedda Reservoir, Narava Village, and Pendurthi Mandal, Visakhapatnam District.



4. Methodology:-

A. Data used for Mapping

- ✓ Location maps of the tanks are from Water resource Department (WRD), Andhra Pradesh Integrated Irrigation and Agricultural Transformation Project (APIIATP).
- ✓ Survey of India (SoI)–1:50,000 Topo sheets (65 O/1, 65 O/2&3 and 65 O/5), latest satellite data of Linear ImagingSelf-Scanning Sensor (LISS - IV).
- ✓ Thematic maps like soils, land use/land cover, drainage, catchment boundaries are drawn on LISS – III.
- ✓ The non-spatial data like command area, beneficiaries, meteorological data are taken from the Department of Earth Sciences and Indian Meteorological Department (DES/IMD).
- ✓ The Resolution that used for mappings are 2.5 for Toposheet and 23.5 for LULC Changes and soil types.

B. Land-cover classification scheme

To prepare the LULC map from satellite imageries, a classification scheme which defines the LULC classes was considered. The numbers of LULC classes are preferred based on the requirement of a specific project for a particular application (Arora and Mathur, 2001; Saha et al., 2005). Level-1, level-2 and level-3 categories were identified following the NRSC (1990) guidelines. Six major LULC classes were chosen for mapping the entire watershed area viz; agricultural land; barren land; built-up land; dense forest; open forest and water-bodies. Area under irrigated agricultural land was included as agricultural land while area under agroforestry was included under open forest due to the similar spectral response of tree covers in agroforestry systems to open forests.

C. SCS- CN curve method:-

The Curve Number Method was originally developed by the Soil Conservation Service (Soil Conservation Service 1964; 1972) for conditions prevailing in the United States. Since then, it has been adapted to conditions in other parts of the world. Although some regional research centers have developed additional criteria, the basic concept is still widely used all over the world. Derivation of Empirical Relationships When the data of accumulated rainfall and runoff for long-duration, high-intensity rainfalls over small drainage basins is plotted, they show that runoff only starts after some rainfall has accumulated, and that the curves asymptotically approach a straight line with a 45-degree slope. The Curve Number Method is based on these two phenomena. The initial accumulation of rainfall represents interception, depression storage, and infiltration before the start of runoff and is called initial abstraction. After runoff has started, some of the additional rainfall is lost, mainly in the form of infiltration; this is called actual retention. With increasing rainfall, the actual retention also increases up to some maximum value: the potential maximum retention. To describe these curves mathematically, SCS assumed that the ratio of actual retention to potential maximum retention was equal to the ratio of actual runoff to potential maximum runoff, the latter being rainfall minus initial abstraction. In mathematical form, this empirical relationship is

$$F/S = Q / P - Ia$$

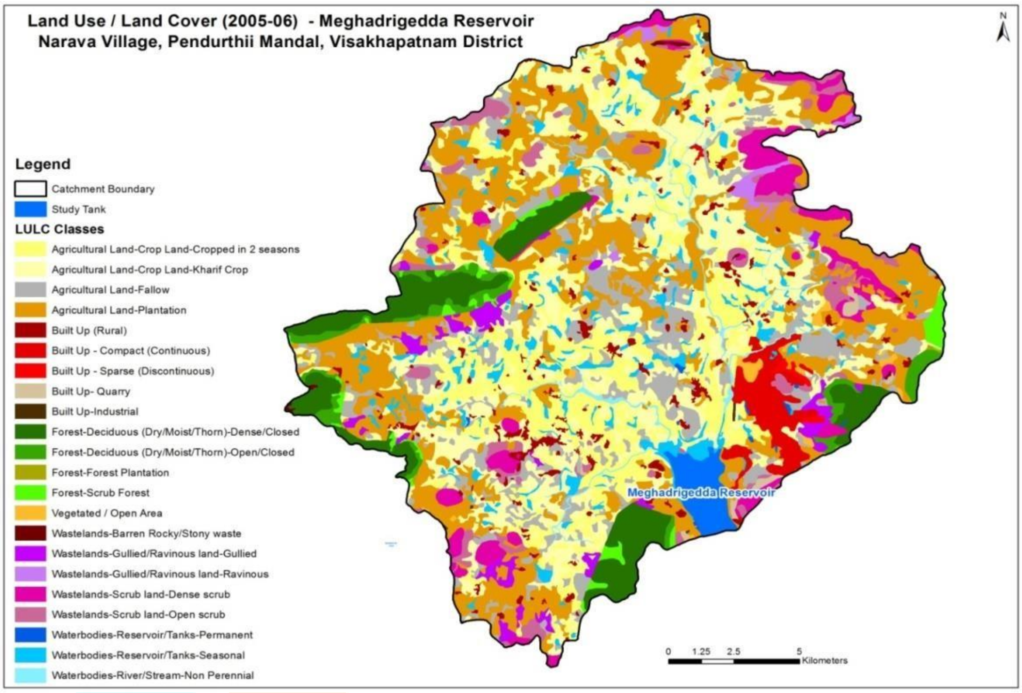
Where,

F = Actual retention (mm)

S = Potential maximum retention (mm)

Q = Accumulated runoff depth (mm)

P = Accumulated rainfall depth (mm)
Ia = Initial abstraction (mm)



Different soil textures were digitized up to boundaries and the polygons representing many soils classes were assigned different colors for recognition. The hydrologic soil groups (HSG) divided into A, B, C and D was carefully thought about in the classification of soils in the watershed. The definition of AMC types depend upon the antecedent five days cumulative rainfall and upon whether the season is growing or dormant one. For modeling purpose, AMC II in watershed is essentially an average moisture condition. Runoff curve numbers from LU/LC and soil type taken for the average condition (AMC-II) and dry condition (AMC-I) or wet condition (AMC-III), equivalent curve number (CN).

Table: Antecedent Moisture Condition (AMC)		
AMC	Total Rain in Previous 5 days	
	Dormant Season	**Growing Season**
I	Less than 13 mm Less than	36 mm
II	13 to 28 mm	36 to 53mm
III	More than 28mm	More than 53mm

$$CN1 = CN2 / 2.334 - 0.01334 CN2$$
$$CN3 = CN2 / 0.4036 - 0.005964 CN$$

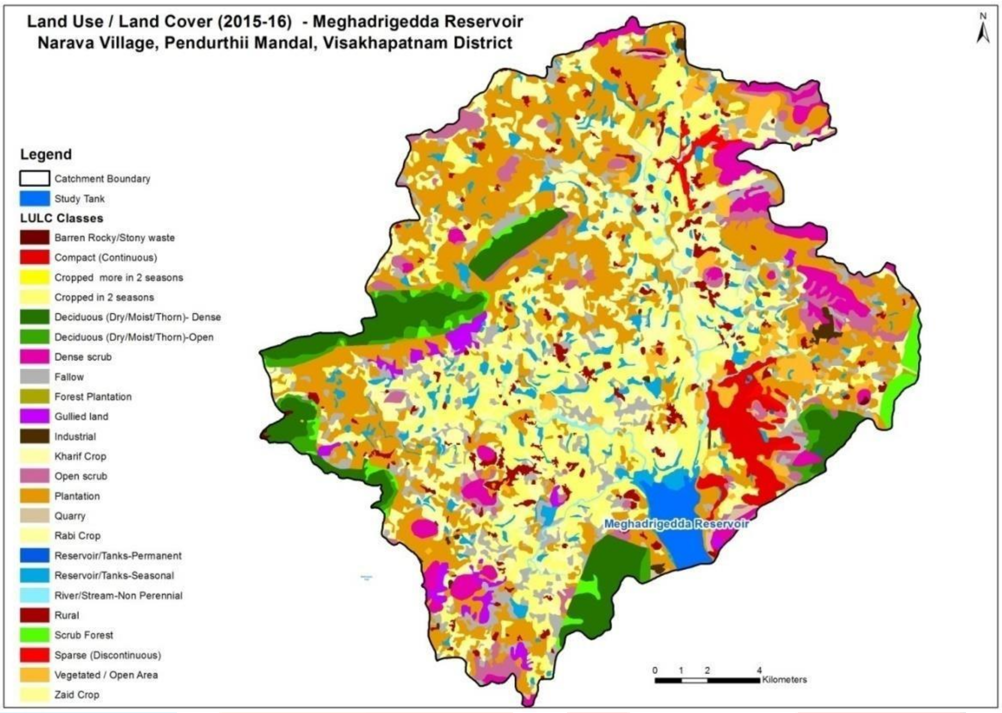
5. Results and Discussion:

I. Transformation of LULC area in the Catchment Boundary:-

The total area of the Catchment boundary of Meghadrigedda Reservoir is 90559.78 Acres (366.5 Ha). From the LULC change detection from 2005-06 to 2015-16, the decadal change 13 Classes have shown an increase in the area and 11 Classes have decreasing pattern.

Map 4:- Below map shows the Land Use / Land Cover (2005-06) - Meghadrigedda Reservoir, Narava Village, and Pendurthi Mandal, Visakhapatnam District.

Map 5:- Below map shows the Land Use / Land Cover (2015 - 16) - Meghadrigedda Reservoir, Narava Village, and Pendurthi Mandal, Visakhapatnam District



IA... ***INCREASED LAND USE / LAND COVER CLASSES IN THE CATCHMENT BOUNDARY:-***

Decreasing order of LULC classes (percentage) in the catchment boundary are following:

Built Up-Industrial (580.55%)> Built Up - Sparse (Discontinuous)(273.05)> Agricultural Land-Crop Land-Cropped More In 2 Seasons(100)> Agricultural Land-Crop Land-Zaid Crop(100)> Agricultural Land-Crop Land-Rabi Crop(100)> Built Up- Quarry(36.19)> Built Up (Rural) (19.19)> Agricultural Land-Crop Land-Cropped In 2 Seasons(15.068)> Agricultural Land-Plantation(9.118)> Forest-Forest Plantation(8.35)> Waterbodies-Reservoir/Tanks-Seasonal(6.71)> Forest-Deciduous (Dry/Moist/Thorn)-Dense/Closed(2.82)> Built Up - Compact (Continuous)(0.50).

Graph 1:- The Below graph shows the Percentage of Increases of LULC from 2005-06 to 2015-16.

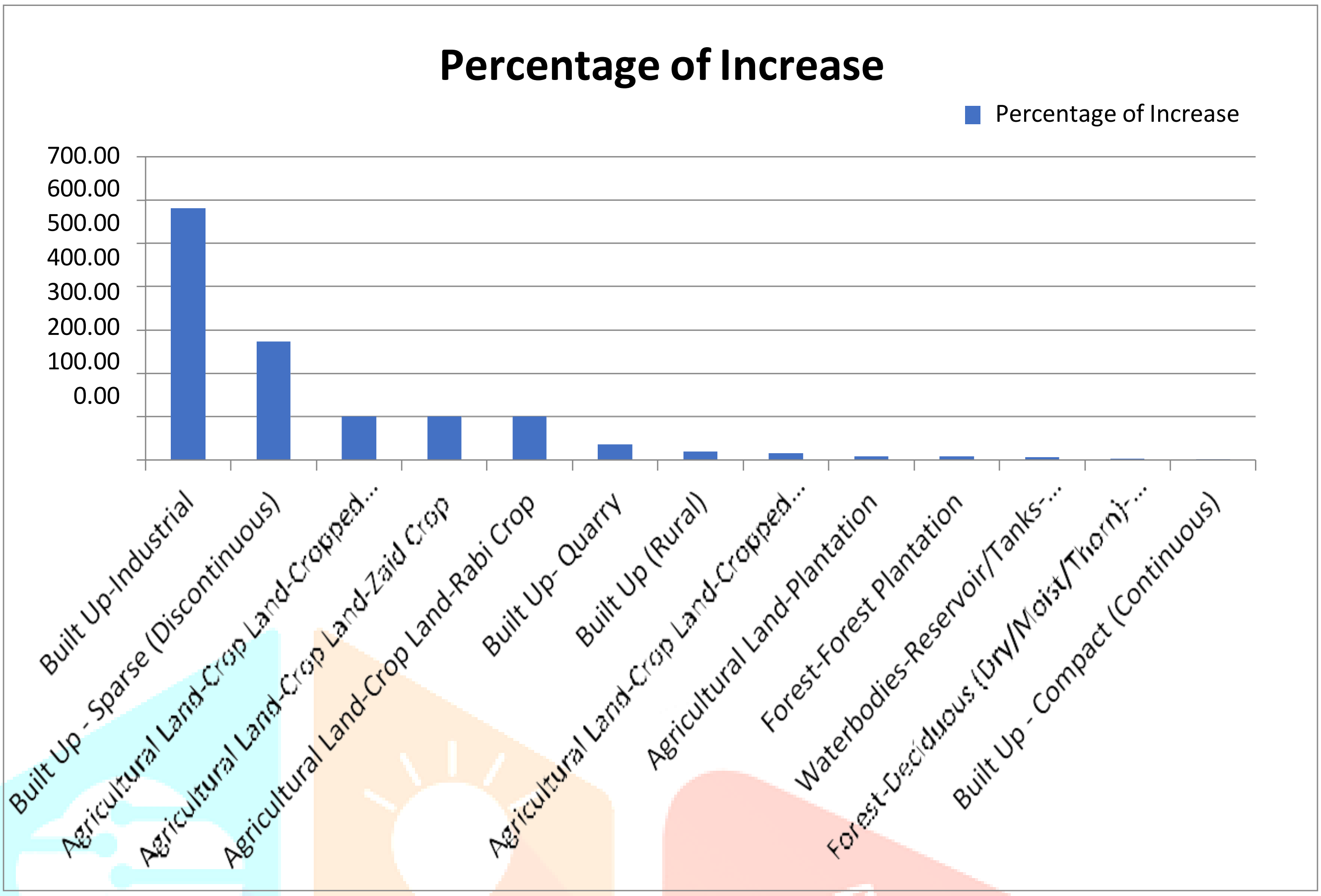


Table 1: Below Table shows the LULC Increased Classes b/w 2005-06 to 2015-16 and Percentage of Increase

S.No	LULC Increased Classes	2005-06	2015-16	Percentage of Increase
1	Agricultural Land-Crop Land-Cropped More In 2 Seasons	0	0.58	100
2	Agricultural Land-Crop Land-Cropped In 2 Seasons	11570.02	13313.41	15.07
3	Agricultural Land-Plantation	22488.06	24538.43	9.12
4	Agricultural Land-Crop Land-Rabi Crop	0	592.3	100
5	Agricultural Land-Crop Land-Zaid Crop	0	133.3	100
6	Built Up - Compact (Continuous)	2058.94	2069.19	0.50
7	Built Up - Sparse (Discontinuous)	166.3	620.39	273.05
8	Built Up (Rural)	2023.81	2412.27	19.19
9	Built Up- Quarry	305.38	415.89	36.19
10	Built Up-Industrial	51.51	350.55	580.55
11	Forest-Deciduous (Dry/Moist/Thorn)-Dense/Closed	5622.86	5781.43	2.82
12	Forest-Forest Plantation	70.67	76.57	8.35
13	Waterbodies-Reservoir/Tanks-Seasonal	4103.76	4379.01	6.71

IB. Decreased Land Use / Land Cover Classes In The Catchment Boundary

Decreasing order of LULC classes (percentage) in the catchment boundary are following:

Wastelands-Barren Rocky/Stony Waste(50.96%)> Wastelands-Gullied/Ravinous Land-Ravinous (41.51%)> Agricultural Land-Fallow (34.93%)> Waterbodies-Reservoir/Tanks-Permanent(22.64%)> Agricultural Land-Crop Land-Kharif Crop (19.16%)> Wastelands-Scrub Land-Dense Scrub(11.24%)> Wastelands-Scrub Land-Open Scrub(10.87%)> Wastelands-Gullied/Ravinous Land-Gullied(4.08%)> Forest-Deciduous (Dry/Moist/Thorn)-Open/Closed(0.56%)> Forest-Scrub Forest(0.19%) = Waterbodies-River/Stream-Non Perennial(0.19%).

Graph 2:- The Below graph shows the Percentage of Decreases of LULC from 2005-06 to 2015-16.

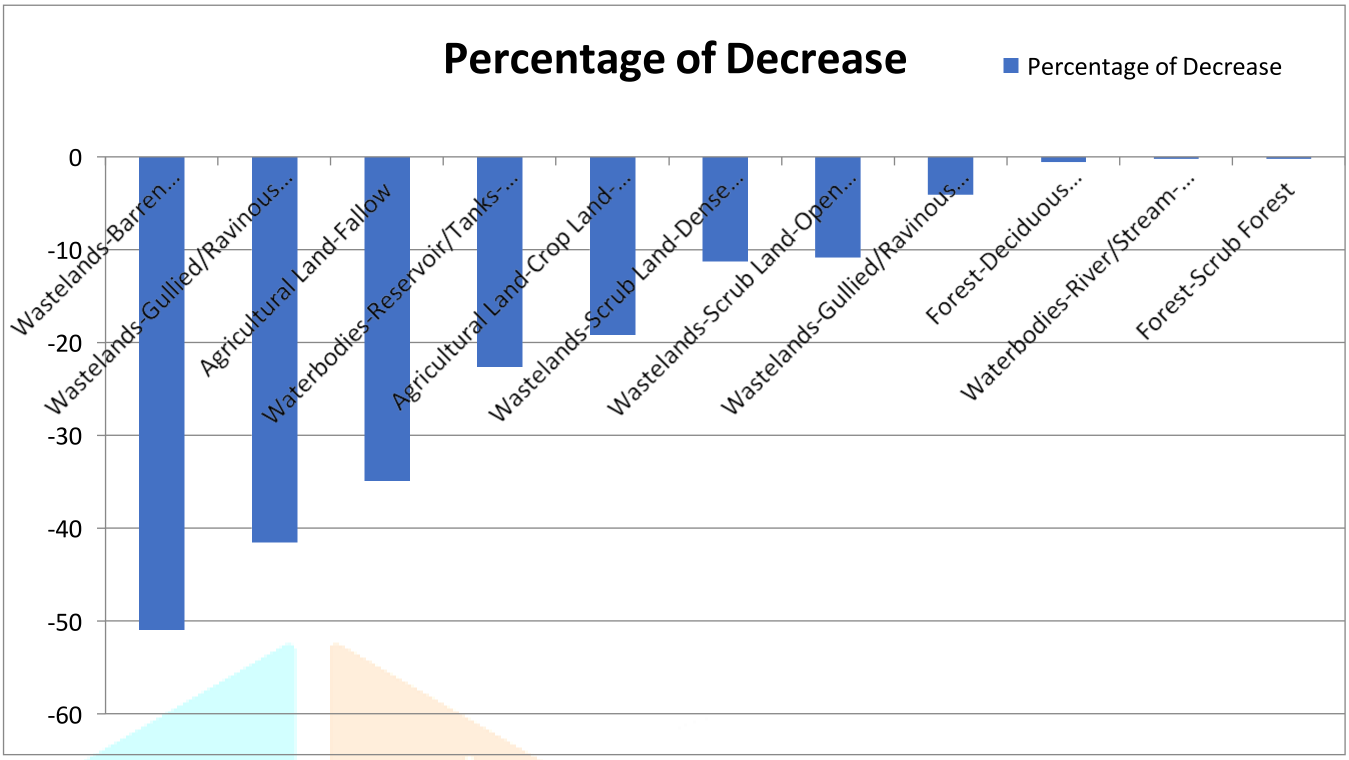
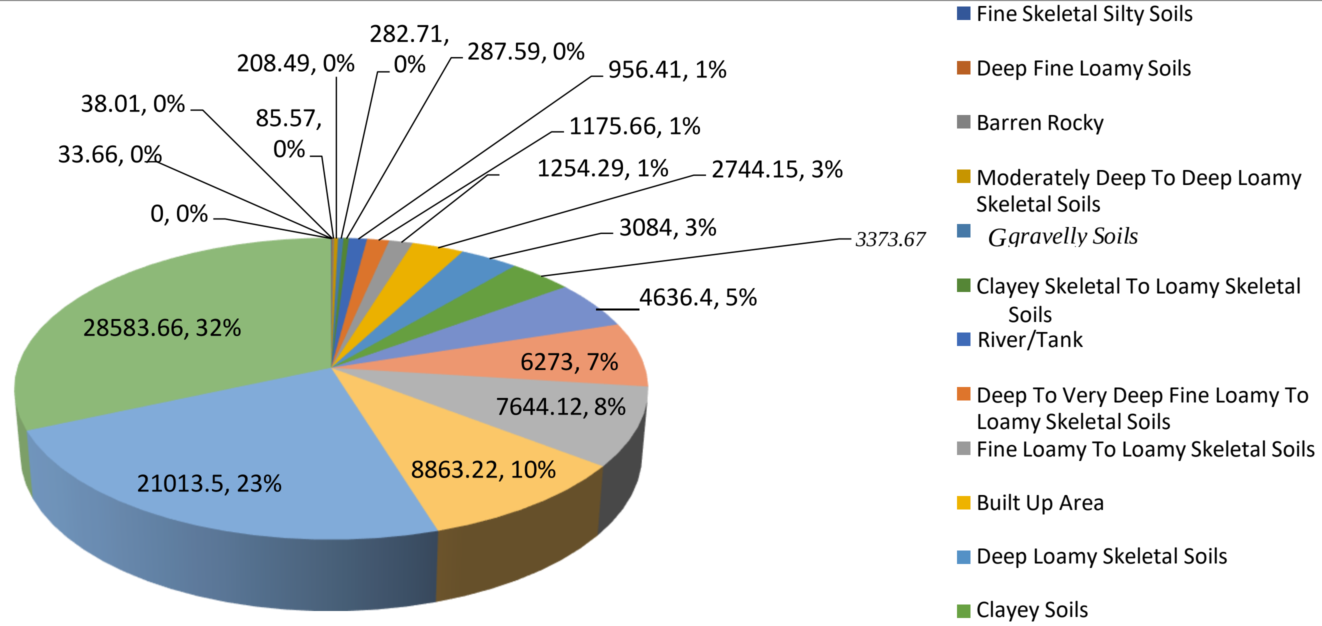


Table 2:-: **Below Table shows the LULC Decreased Classes b/w 2005-06 to 2015-16 and their Percentage ofDecrease**

S.No	LULC DECREASED CLASSES	2005-06	2015-16	rcentage of Decrease
1	Agricultural Land-Crop Land-Kharif Crop	18385.23	14862.66	-19.16
2	Agricultural Land-Fallow	9455.75	6152.62	-34.93
3	Forest-Deciduous (Dry/Moist/Thorn)-Open/Closed	1648.2	1639.03	-0.56
4	Forest-Scrub Forest	957.16	955.34	-0.19
5	Wastelands-Barren Rocky/Stony Waste	98.75	48.43	-50.96
6	Wastelands-Gullied/Ravinous Land-Gullied	1698.18	1628.97	-4.08
7	Wastelands-Gullied/Ravinous Land-Ravinous	591.81	346.17	-41.51
8	Wastelands-Scrub Land-Dense Scrub	3820.14	3390.58	-11.24
9	Wastelands-Scrub Land-Open Scrub	2967.16	2644.59	-10.87
10	Waterbodies-Reservoir/Tanks-Permanent	1127.69	872.4	-22.64
11	Waterbodies-River/Stream-Non Perennial	899.04	897.33	-0.19

II. Soil Types:-

Soil plays key role in the watershed management, based on the soil type the water availability from rain fall in the catchment is being decided. The 5 major soil types i.e.., Fine Soils (32%), Loamy Skeletal Soils (23%), Deep to Very Deep Fine Soils (10%), Deep To Very Deep Fine Loamy Soils(8%), Fine Loamy Soils(7%) contribute 80% of the land area in the catchment. Clay soils consist of 4% of the area. The study area contains hydrologic soil groups of C and D. The soil group of C indicated moderately fine to moderately rough textures, moderate rate of water transmission and the soil of group D indicated slow infiltration and possible high runoff.



Graph 3:- The Below graph shows the Soil Types and Their Percentage in the Catchment area

Map 6:- Below map shows the Soil Types - Meghadrigedda Reservoir, NaravaVillage, and Pendurthi Mandal, Visakhapatnam District

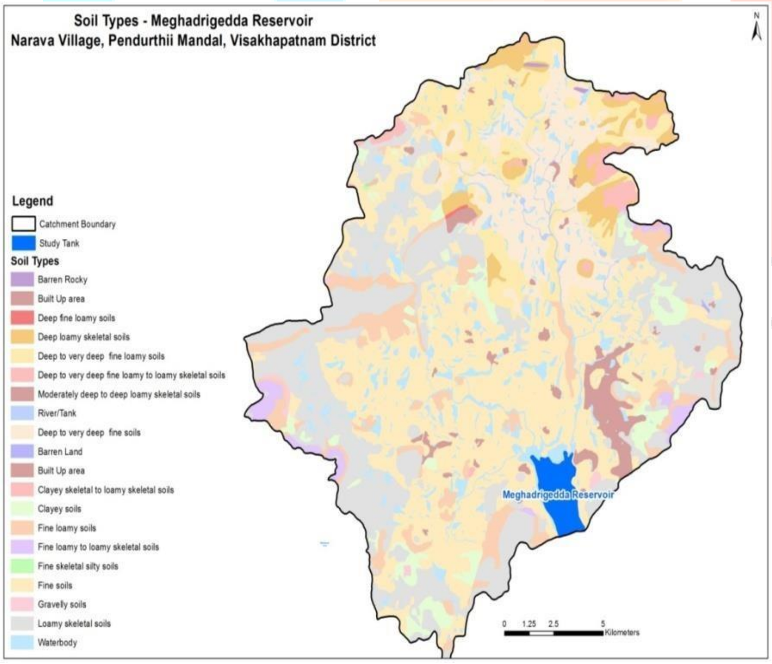


Table 3: Below Table shows the Soil Types and area

Meghadrigedda Reservoir	Area in Acres
Barren Land	21.38
Barren Rocky	85.57
Built Up Area	2744.15
Clayey Skeletal To Loamy Skeletal Soils	287.59
Clayey Soils	3373.67
Deep Fine Loamy Soils	38.01
Deep Loamy Skeletal Soils	3084.00
Deep To Very Deep Fine Loamy Soils	7644.12
Deep To Very Deep Fine Soils	8863.22
Deep To Very Deep Fine Loamy To Loamy Skeletal Soils	1175.66
Fine Loamy Soils	6273.00
Fine Loamy To Loamy Skeletal Soils	1254.29
Fine Skeletal Silty Soils	33.66
Fine Soils	28583.66
Gravelly Soils	282.71
Loamy Skeletal Soils	21013.50
Moderately Deep To Deep Loamy Skeletal Soils	208.49
River/Tank	956.41
Waterbody	4636.40

III. Rainfall and Runoff:-

Average yearly rainfall of the catchment boundary varies from 342.2 mm to 1502.2mm. The runoff varies102.66 mm to 450.66. Runoff is mainly dependent on soil type, Land Use & Land Cover, Moisture condition existing in the soil. The catchment area receives average annual rainfall of 1202 mm, of which South-West monsoon accounts for 55.9% of the normal while North-East monsoon contributes 6.8% of the normal rainfall. (Abbulu.Yetal 2013).

Graph 4:- The Below graph shows the Monthly Average Rainfall

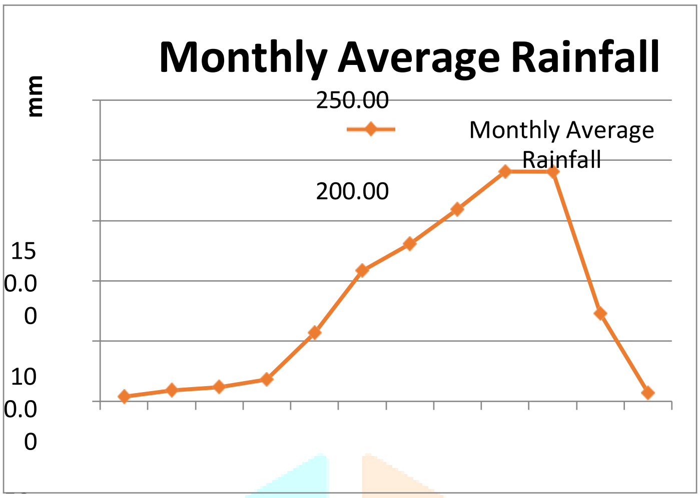
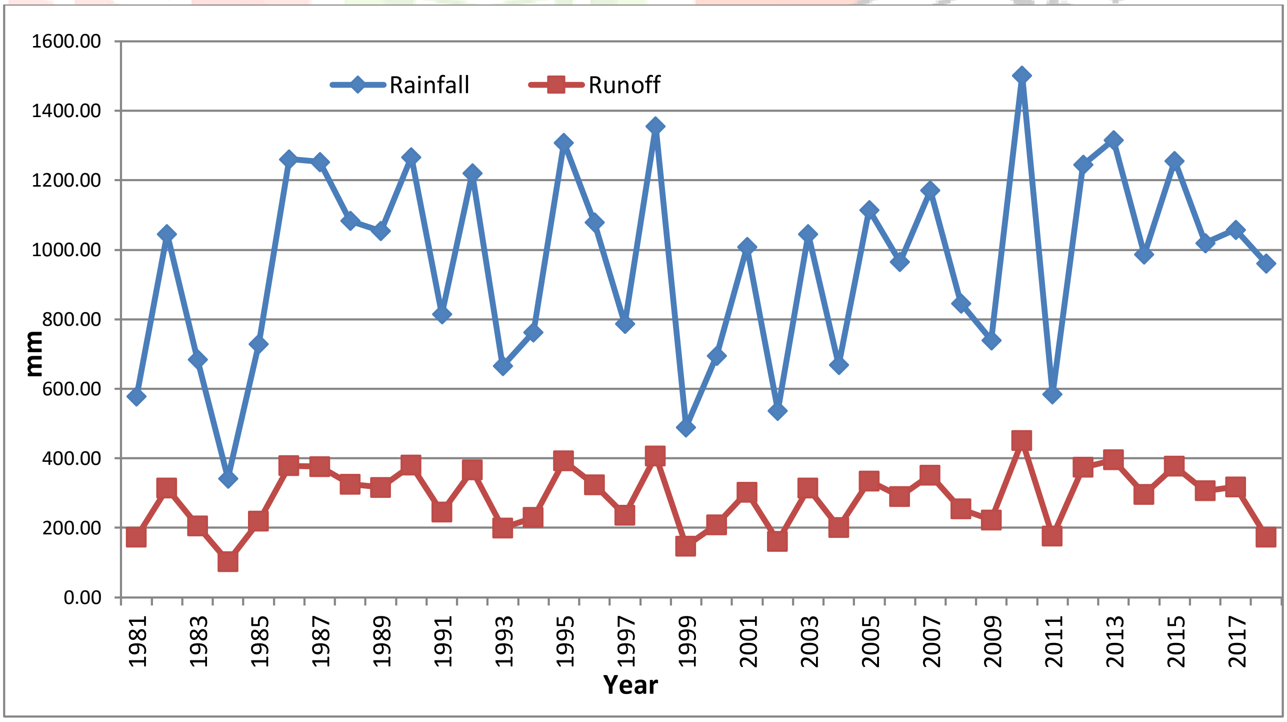


Table 4: Below Table shows the Rainfall from 1981-17and Runoff estimation during the same period

Year	Rainfall	Runoff	Year	Rainfall	Runoff
1981	578.4	173.52	2000	695.1	208.53
1982	1045.5	313.65	2001	1008.4	302.52
1983	684	205.2	2002	537.2	161.16
1984	342.2	102.66	2003	1045.3	313.59
1985	729.1	218.73	2004	668.9	200.67
1986	1260.5	378.15	2005	1114.9	334.47
1987	1253.2	375.96	2006	965.3	289.59
1988	1083.2	324.96	2007	1171.2	351.36
1989	1053.9	316.17	2008	846.2	253.86
1990	1266.7	380.01	2009	740	222
1991	814.9	244.47	2010	1502.2	450.66
1992	1219.9	365.97	2011	584.4	175.32
1993	665.4	199.62	2012	1244.6	373.38
1994	763.1	228.93	2013	1316.2	394.86
1995	1308.3	392.49	2014	986.4	295.92
1996	1079.1	323.73	2015	1255.8	376.74
1997	787.1	236.13	2016	1019.4	305.82
1998	1355	406.5	2017	1058	317.4
1999	489.4	146.82			

Graph 5:- The Below graph shows Year wise Average Rainfall and Rainfall Runoff estimation By using the SCS – CN Curve Method

Year wise Average Rainfall:-



IV. Field observations:-

- There is a farming of various vegetables and Banana fields beside the Reservoir by pumping of water throughdiesel pumps.
- Observed that some people from the local villages are doing the fishing activities in the reservoir.
- On the surface of water there is huge amount of non-degradable substances like paper and plastic covers & bottlesetc..,
- Open air defecation was take place in edge of the reservoir.

- Ground truth verification was done within the catchment area. The changes in Land use and land cover patterns observed and were recorded in mapping.

6. Conclusions & Suggestions:-

From the mapping of LULC classification highest percentage increase class is Built Up-Industrial from 51.51Acres to350.55 Acres with 580.55% in the catchment area. The mapping of LULC classification lowest percentage increase class is Built Up - Compact (Continuous) from 2058.94Acres to 2069.19 Acres with 0.50 % in the catchment area. In the mappingof LULC classification highest percentage decrease class is Wastelands-Barren Rocky/Stony Waste from 98.75 Acres to

48.43 Acres with 50.96% decrease in the catchment area. From the mapping of LULC classification lowest percentage decrease classes are Forest-Scrub Forest from 957.16 Acres to 955.34 Acres with 0.19 % decrease and Waterbodies-River/Stream-Non Perennial from 899.04 Acres to 897.33Acres with 0.19 % decrease in the catchment area. By using the SCS-CN method, the rainfall runoff was estimated and find that highest runoff was during 2010 (450.66 mm) and lowest runoff was recorded in 1984 (102.66 mm).

The feeder channels of the water bodies are either choke with vegetation or disruptive with local constructions through illegal operations which results in low inflow into existing water bodies. The changes in the catchment area observed as the existing farm lands are diverted either into real estate business or industrial purpose. From the satellite images, it is also observed the discharges from the residential areas are causing change in water bodies which in turn alter in the biodiversity in the area. LG Polymers is located at 3km to 5km radius of Meghadrigedda reservoir and being tested to determine whether the gas leak at LG Polymers has affected the quality of the water. Following the leak, apprehensions were expressed over the safety of the reservoir's water, prompting the Greater Visakhapatnam Municipal Corporation to suspend supply of drinking water from Meghadrigedda until its water is found to be safe. Drinking water is now being supplied to the city from Yeleru, Mudasarlova and Tatipudi reservoirs. At present the responsibility for the protection of boundaries of water bodies lies with the State Governments, as they are the absolute owners of water bodies located in their State. 'Water' being a State subject, several steps for augmentation, conservation and efficient management to ensure sustainability of water resources are undertaken by the respective State Governments.

***References**:-*

- Cole, R. A., Feather, T. D., & Letting, P. K. (2002).Improving watershed planning and management through integration: A critical review of federal opportunities. Pre-pared for US Army Corps of Engineers, Institute of Water Resources by of Planning and Management Consultants, Ltd. Contract# DACW72-99-D-0005, Task Order, 61.
- Dash, P. K., Dash, T., & Kara, P. K. (2011). The role of local institutions in sustainable watershed management: Lessons from India. Development in Practice, 21(2), 255e268.
- EPA. (1996).Watershed approach frame work. Washington, DC, USA: U.S. Environ-mental Protection Agency.
- Erdogan, R. (2013). Stakeholder involvement in sustainable watershed management. In Advances in landscape architecture. Intech Open.
- Gebretsadik, T., & Debara, M. (2017). Assessment of knowledge, attitude and practice of the local community on watershed management at Kindo KoyshaWoreda of Wolayta zone, Southern Ethiopia. International Journal of Agriculture,2(1), 1e17.
- Gupta, M., Goyal, V. C., Tarannum, F., & Patil, J. P. (2017). Designing a watershed scorecard as a performance evaluation tool for Ur River watershed, Tikamgarh District, Madhya Pradesh. International Soil and Water Conservation Research,5(4), 280e292.
- Hill, R. (1998). What sample size is "enough" in internet survey research. Inter-personal Computing and Technology: An Electronic Journal for the 21st Century,6(3e4), 1e10.
- Javarayigowda, N. H., Basavaraju, G. K. S., & Jayaram, S. H. (2018). Morphometric analysis of Karadya micro watershed: A case study of Mandya district. American Journal of Remote Sensing, 6(1), 15.
- Kerr, J. (2007). Watershed management: Lessons from common property theory. International Journal of the Commons, 1(1), 89e109.
- Kiran, V. S. S., Rao, J., & GT, V. K. (2016). Block level micro watershed prioritization based on Morphometric and runoff parameters. International Journal of Advanced Remote Sensing and GIS, 5, 1981e1987.
- Legesse, A., Bogale, M., & Likisa, D. (2018). Impacts of community based watershed management on land use/cover change at elemo micro-watershed, Southern Ethiopia. American Journal of Environmental Protection, 6(3), 59e67.
- Mondal, B., Singh, A., Sekar, I., Sinha, M. K., Kumar, S., & Ramajayam, D. (2016).Institutional arrangements for watershed development programmes in Bundelkhand region of Madhya Pradesh, India: An explorative study. International Journal of Water Resources Development, 32(2), 219e231.
- Narmada, K., Gobinath, K., & Bhaskaran, G. (2015). An assessment of resource potentials for sustainable developmentof micro-watershed in Tirunelveli district using geoinformaticse. A case of Nambiyar micro-watershed in Tirunelveli district, Tamil Nadu, India. Aquatic Procedia, 4, 1299e1306.
- Rajan, K., Sudhirendar, S., Eklabya, S., & Hofer, T. (2017).Everybody lives upstream: The watershed approach for the changing climate of the Hindu Kush Himalaya. ICIMOD Working Paper, (2017/11).
- V.N. Sharda. "Integrated Watershed Management: Managing Valleys and Hills in the Himalayas'' International Water Management Institute, South Regional Office, New Delhi/Patancheru, India, 2005 Pp.61-81
- Suhas P. Wani and Y.S. Ramakrishna ''Sustainable Management of Rainwater through Integrated Watershed Approach for Improved Rural Livelihoods' International Water Management Institute, South Asia Regional Office, New

Delhi/Patancheru, India, 2005 Pp.39-6o

- Pat O'neill, Ben Higgins, and Christine Rohrer "Applying Integrated Watershed Management Techniques In Stevens Creek", Water Environment Foundation 2006.
- Bharat R. Sharma and Christopher A. Scott "Watershed Management Challenges: Introduction and Overview'' International Water Management Institute, South Asia Regional Office, New Delhi/Patancheru, India, 2005 Pp.1-21.
- Government of India, Common Guidelines for Watershed Development Projects. National Rain-fed Area Authority (Ministry of Land Resources, Government of Andhra Pradesh, India. 57, 2001).
- Fulcher, C., Prato, T., Zhou, Y., 1996. Watershed management decision support system. In: Proceedings of the Watershed 96: Moving Ahead Together Technical Conference and Exposition. Baltimore, MD, pp. 790–793.
- Jenson, S.K., Domingue, J.O., 1988. Extracting topographic structure from digital elevation data for Geographic Information System analysis. Photogrammetric Engineering and Remote Sensing 54 (11), 1593–1600.
- Wilson, J.P., 1996. GIS-based land surface/subsurface modeling: new potential for new models In: Proceedings of the third International Conference/Workshop on Integrated Geographic Information Systems and Environmental Modeling.