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A Geo-Spatial Approaches for Integrated Watershed Management (IWM): Case Study of Boni Mukundaraju Cheruvu, Andhra Pradesh, India

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Abstract*: Sustainable management of available water resources and judicious allocation to user needs within the ecosystem threshold can be achieved through Remote Sensing. To estimate the surface features with the help of change analysis which improves better resource management and decision-making in watershed hydrology assessment, interactions and relationships between human activities and natural phenomena are important. The present study on Geo-spatial approaches for Watershed management of Boni Mukundaraju cheruvu in Visakhapatnam district, Andhra Pradesh, India. From the study, we fixed it that the LULC of study area was classified into 5 major classes and 13 sub classes. During the study period from 2010-11 to 2020-21, it was observed that the wastelands in the catchment area were converted into water bodies seasonal and agricultural lands. It is also observed that the forest area was increased and majorly built up area was decreased from 2010-11 to 2020-21. The present study brings out the potential of geospatial techniques in LULC changes from 2010-11 to 2020-21, drainage patterns, Hydrological soil types (4types) and rainfall-runoffs from 1991-2021 (30 years) were described in detail.

Keywords: Watershed Management, Lulc, Scs-Sn Method, Geo-Spatial Techniques, HSG.

I. INTRODUCTION

Water exists in different forms such as rainfall, river water, ground water, ponds and lakes etc. The planet earth surface is covered with water which is about 71% and the oceans account for 96.5% of Earth's total water. Two-thirds of water is locked up in glaciers and permanent snow cover while remaining one-third is distributed regionally with wide disparities (Bindu and Abdul Razak, 2015). Water is a very vital nutrient which plays a key role in the functioning of human body. Water plays a very significant role on the earth surface. The functional attributes of water include drinking and daily activities, climatic comfort, recreational facilities, transportation facilities, religious facilities, etc. Surface water bodies are critical freshwater resources from human and ecological perspectives. The surface water bodies are paramount importance in sustaining all forms of lives (Karpatne et al., 2016). Water plays an important role and it helps in preserving the biodiversity in riparian or wetland ecosystems by providing habitats to the flora and fauna (Vorosmarty et al., 2010). In India, the Composite Water Management Index (CWMI) report released by the NITI Aayog in 2018 indicate that 21 major cities (Delhi, Bangalore, Chennai, Hyderabad and others) are racing to reach zero groundwater levels soon, affecting access for 100 million people. As per the data released in April 2014 by Ministry of Drinking Water and Sanitation, Andhra Pradesh ranks 15th place among the Indian states with only 35% of habitations fully covered with drinking water supply. By 2025, 1/3rd of the world's population will experience severe water scarcity unless appropriate mitigation measures are taken (David 2002). Remote Sensing (RS) and Geographic Information Systems (GIS) techniques provide effective tools for analyzing the land use dynamics of the region by sound planning and cost- effective tool in decision making (Giriraj et al., 2008). They are efficient tools for analysis and planning and modeling of land uses as well as for monitoring, mapping and management of natural resources (Prakasam 2010). Santillan et al. (2010) explained about an integrated approach involving RS and GIS for predicting land cover change impacts on surface runoff and sediment yield in a critical watershed in Mindanao, Philippines. These models would be useful for watershed management, planners and decision makers in lessening runoff and sediment yield. Kinthada et al. (2013) reported on the importance of Geo-morphometry with respect of utility of remote sensing and GIS technology in hydrological characterization of the basin at micro- watershed level.

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II. STUDY AREA

Boni Mukundaraju Cheruvu is located at Boni village, Anandapuram mandal, Visakhapatnam district. It has 3957.642 cares (16.02 Sq.kms) of catchment area which is covered in Anandapuram and Bheemunipatnam mandals of Visakhapatnam district in Andhra Pradesh, India (figure 1). The ayacut is 715 acres and having 44.69 Mcft of storage capacity.

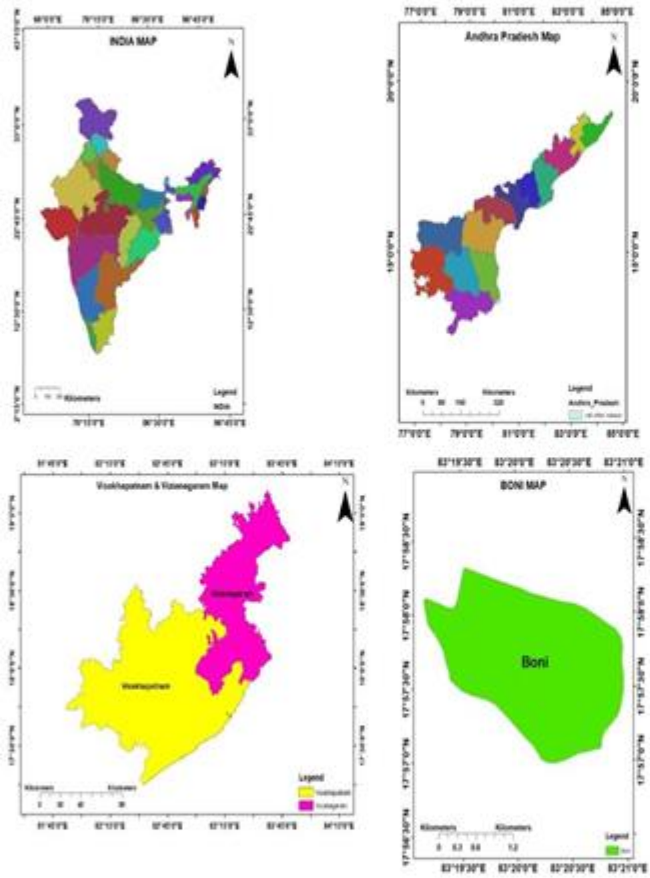

Fig 1. Location map of mukundaraju cheruvu

III. METHODOLOGY

GIS database like Location map, Drainage map and LULC map were prepared with the help of software ArcGIS 10.2.2.1 desktop version and ERDAS IMAGINE 2015 for true representation of the study water bodies. Secondary data like meteorological data, the storage capacity of reservoirs and thematic maps like soils were obtained from NRSA raw data, India Meteorological Department, Visakhapatnam and Greater Visakhapatnam Municipal Corporation, Visakhapatnam.

3.1. Drainage Maps:

Drainage network was generated in GIS environment using ArcGIS and ASTER-GDEM Version-3 (30 mt spatial resolution). Drainage pattern of a basin is influenced by various determinants like initial slope, lithologic and structural inequalities, recent diastrophism, geologic and geomorphic histories of drainage basin and is extremely helpful in the interpretation of geomorphic features and the structural and lithological control of landform evolution.

3.2. LULC Classification:

Spatial data in the form of satellite imageries for the preparation of Land Use/Land Cover details for the study area were procured from NRSA raw data, Sentinel data. These satellite imageries for the Boni Mukundaraju Cheruvu of the year 2010-11 and 2020-21 pertain to Indian Remote Sensing Satellite (IRS)-P6, Linear Imaging and Self Scanning Sensor-III (LISS–III) with a resolution of 23.5m. The collected satellite imageries were geo-referenced in ERDAS 2015 then rectified and finally projected. The delineated watershed in vector form was covered on projected satellite imagery to get the sub-set of the study areas. Normalized Difference Vegetation Index (NDVI) was working as the basis for Land Use/Land Cover classification. This method of classification has been found to be suitable for the study area as the data used was pertaining to the past period i.e., years 2010-11 to 2020-21 and also the study area is much large comprising predominantly of vegetation. Study area has been classified for Land Use/Land Cover into five classes, water bodies, agriculture crop land, built up area, wastelands and forest area in ERDAS 2015. Area under all classes has been calculated from the attribute table. The classified thematic map was converted from raster to vector format in Arc GIS 10.3.1 for furtheranalysis.

3.3. Lulc Change Analysis:

Land use/land cover base map was prepared from Survey of India topo sheets and placed on satellite imagery and identified the locations of classes. Built-up area included buildings, industrial establishments, transportation network, and commercial centers. Change detection maps were developed for urban sprawl, water bodies and vegetation changes. The LULC maps were prepared by using satellite imagery of LISS-III and LISS-IV for the years 2010-11 and 2020- 21 of three cropping seasons i.e., kharif, rabi and Zaid. Various image enhancement techniques were adapted to make the imagery more interpretable.

IV. RESULTS AND DISCUSSION

4.1. Drainage patterns of study area:

The Mukundaraju Cheruvu exhibits dendritic drainage patterns. There were 17 intercepted tanks which were designated as “small Kuntas” in the catchment boundary. The surface water bodies and drainage patterns were demarcated on topo sheet as shown in Figure 2.

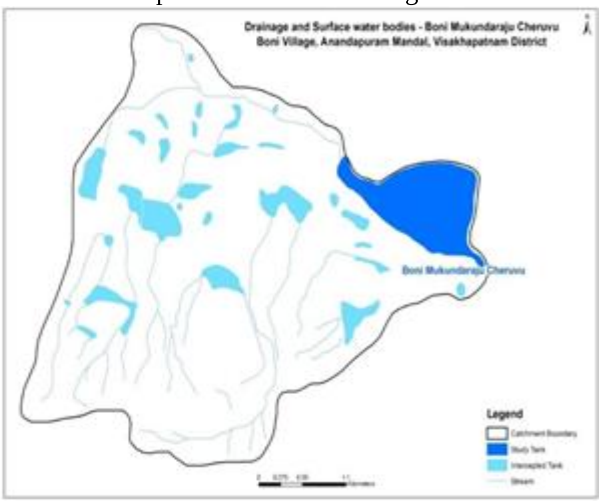

Fig 2. Drainage Networks and surface water bodies in the catchment boundary of Mukundaraju Cheruvu

4.2. LULC Classification:

The Mukundaraju Cheruvu covers an area of 3957.64 acres. LULC of the reservoir basin has been classified into 5 major classes and 13 sub-classes.

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The major LULC classes of the catchment area observed during the study period included agriculture (64.76%), water bodies (15.81%), forest area (15.01%), wastelands (2.48%) and built-up area (1.75%) as shown in Table1 and Figure 3.

Tab 1. Major LULC classes of Mukundaraju Cheruvu and its percentage to Total catchment area (TCA)

S. No	Major LULC Classes	Area (acres)	Percentage to TCA
1	Agricultural land	2563.03	64.76
2	Built-up area	69.43	1.75
3	Forest area	593.93	15.01
4	Wastelands	98.24	2.48
5	Waterbodies	625.84	15.81

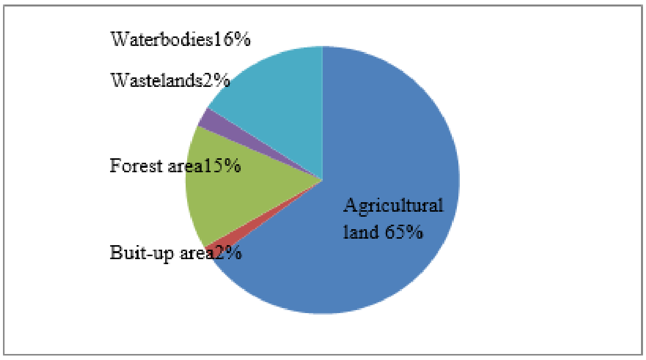

Fig 3. Major Lulc Classes of Mukundaraju Cheruvu

In agriculture class, 5 sub-classes were identified. They were agricultural land-crop land- cropped in 2 seasons (23.17%), agricultural land-crop land-kharif crop (14.54%), agricultural land-plantation (12.12%), agricultural land-fallow (8.71%) and agricultural land-crop land-rabi crop (6.22%). Waterbodies area covers a total of 15.81% of total catchment area.

It is divided into 2 sub-classes which included waterbodies-reservoir/tanks-seasonal (12.23%) and waterbodies-reservoir/tanks-permanent (3.59%).

Forest area class of the catchment area covers a total of 15.01% with 2 sub-classes which include forest-scrub forest (14.77%) and forest-forest plantation (0.23%). Wasteland covers 2.48%, of the total catchment area in which 2 sub-classes have been identified. They included wastelands-scrub land-open scrub (1.55%) and wastelands-gullied/ravenous land-gullied (0.93%). Built up area class contributes to 1.75% of the total catchment area. It is divided into 2 sub-classes which included built up (rural) (1.44%) and built up quarry (0.31%) respectively.

4.3. LULC Change detection: -

The basic method to quantify the LULC change is to tabulate the changes for each category and subsequently examine the increasing or decreasing trends and major changes in categories between the years of 2010-11 to 2020-21 as shown in Figures 4 and 5.

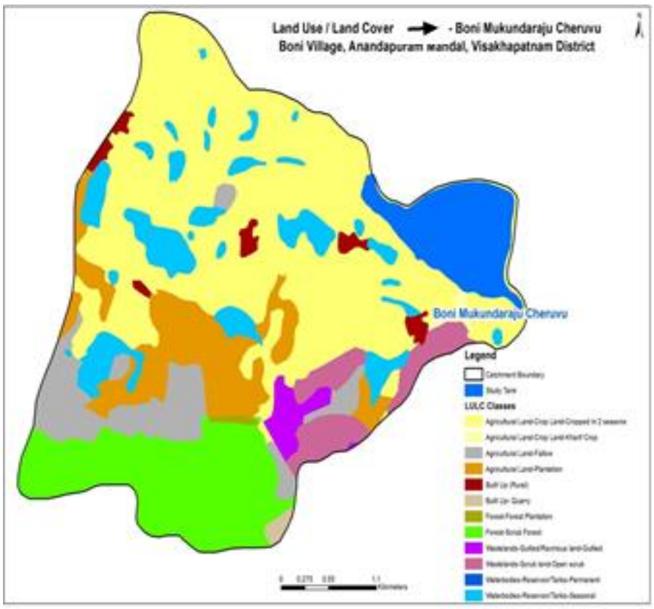

Fig 4. Lulc in the catchment boundary of study tank (2010-11)

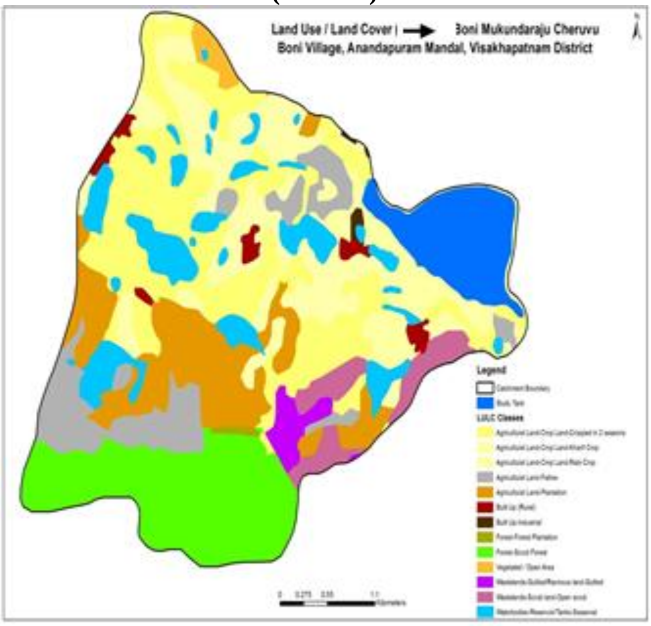

Fig 5. Lulc in the catchment boundary of study tank (2020-21)

V. REVIEW CRITERIA

This journal uses double-blind review process, which means that both the reviewer (s) and author (s) identities concealed from the reviewers, and vice versa, throughout the review process. All submitted manuscripts are reviewed by three reviewer one from India and rest two from overseas. There should be proper comments of the reviewers for the purpose of acceptance/ rejection. There should be minimum 01 to 02 week time window for it. In the Mukundaraju Cheruvu catchment area, it was observed that the waterbodies were increased by 22.54% (141.06 acres) from 484.78 acres to 625.84 acres followed by Forest area increased by 5.71% (33.91 acres) from 560.02 acres to 593.93 acres.

Three major LULC classes showed the decrease in terms of net area, which includes the wasteland, was decreased by 57.32% (131.92 acres) from 230.16 acres to 98.24 acres and built-up area was decreased by 2.43% (1.73 acres) from 71.16 acres to 69.93 acres and agricultural land was decreased by 1.86% (48.89%) from 2,611.52 acres to 2,563.03 acres respectively as shown in Table 2 and Figure 6.

Tab 2. Lulc changes in major classes in the catchment boundary of study tank (2010-11 to 2020-21)

S. No	LULC Major Classes	2010-11 (Area in acres)	2020-21 (Area in acres)	Changes in acres	Change in %
1	Agricultural land	2,611.52	2,563.03	-48.49	-1.86
2	Built-up area	71.16	69.43	-1.73	-2.43
3	Forest area	560.02	593.93	33.91	5.71
4	Wastelands	230.16	98.24	-131.92	-57.32
5	Waterbodies	484.78	625.84	141.06	22.54

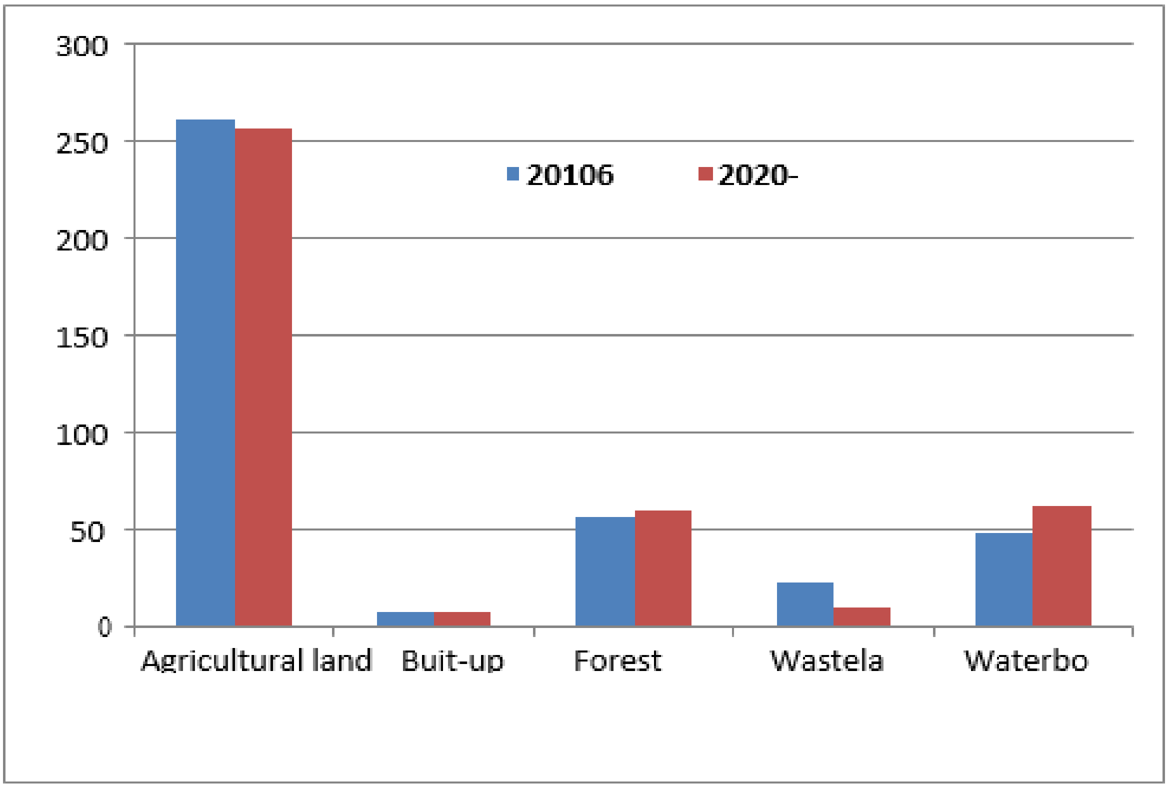

Fig 6. Lulc changes in major classes in the catchment boundary of study tank (2010-11 to 2020-21)

4.4. HSG's of study area: -

The HSG's of Mukundaraju Cheruvu divided into four groups of which moderately low runoff covered with major portion (1,622.63 acres) followed by low runoff (1,503.90 acres), moderately high runoff (474.92 acres) and high runoff (356.19 acres) respectively as shown in Table 3 and its percentage distribution is shown in Figure 7.

TAB 3. HSG'S of Study Area

S. No	HSGs of study area	Area in acres	Area in %
1	Low runoff	1,503.90	38
2	Moderately Low runoff	1,622.63	41
3	Moderately High runoff	474.92	12
4	High runoff	356.19	9

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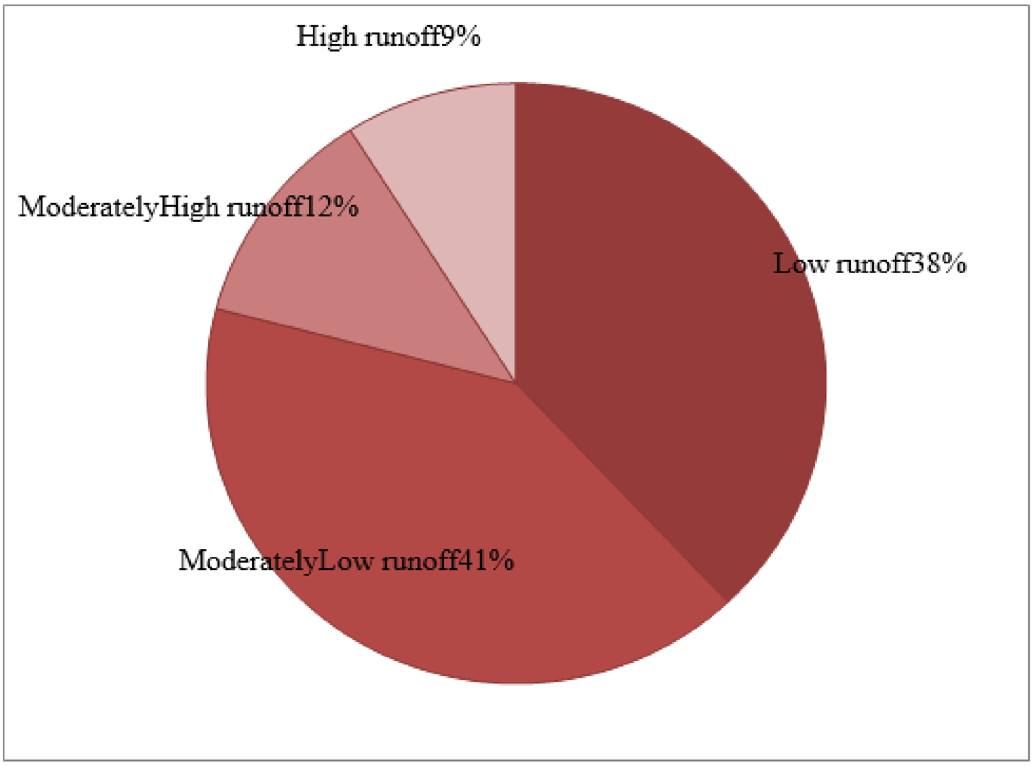

Fig 7. Hsg's and its distribution percentage of mukundaraju cheruvu

4.5. Rainfall and Runoff Estimation by Using SCS-CN Method: -

The major rain gauge station is located at Anandapuram mandal and the total catchment area was 3957.64 acres. The storage capacity of tanks and reservoirs was about 44.69 Mcft and having 715 acres of ayacut was registered under this Mukundaraju Cheruvu.

The average annual rainfall of the catchment area of Mukundaraju Cheruvu from 1991- 2021 (30 years) is 1,092.91 mm and average annual rainfall-runoff of the catchment area was 334.35 mm. Rainfall and runoff of the study area from past 30 years was plot on graph as shown in below Figure 8.

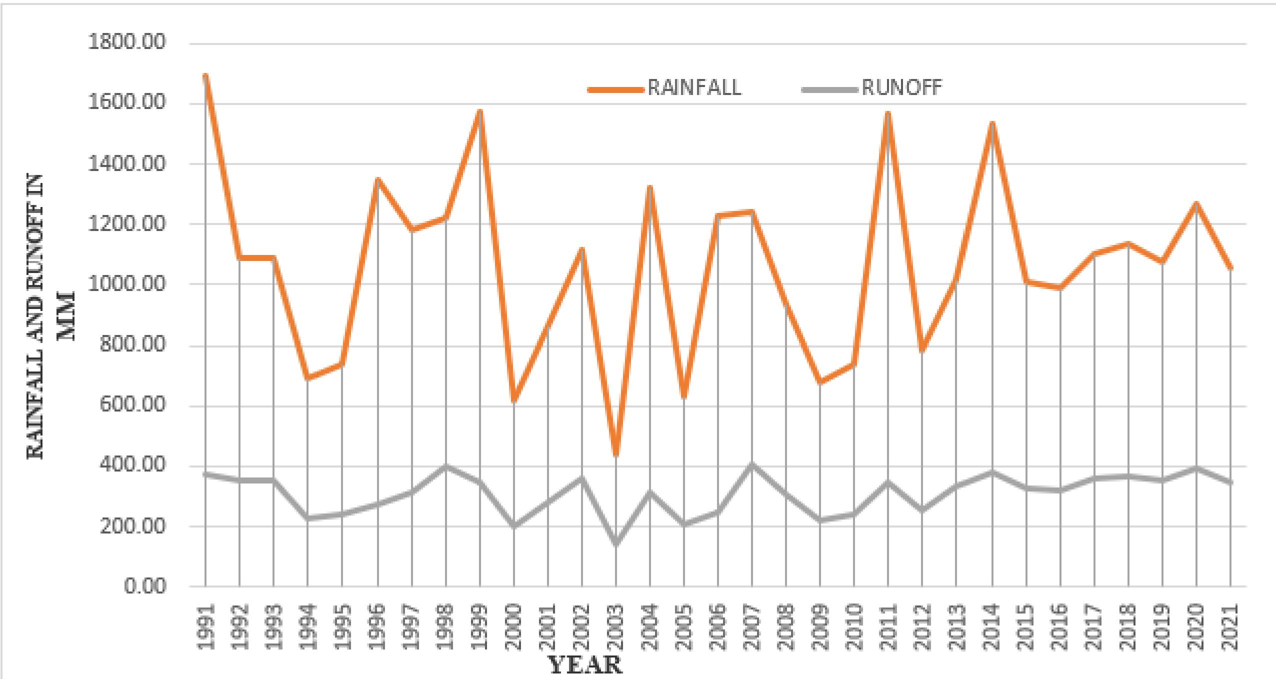

Fig 8. Average Annual Rainfall and Runoff of Study area

VI. SUMMARY AND CONCLUSIONS

A sustainable water management is need of the hour to conserve water from root level to win in a fierce battle against water crisis and to meet Sustainable Development Goals (SDGs) by 2030. In the present study, assess the LULC changes in a decade from 2010-11 to 2020-21 by using Remote sensing and GIS technologies and assess the rainfall runoff using SCS-CN method in the catchment area of Mukundaraju Cheruvu.

The study carried out on the LULC changes of Mukundaraju Cheruvu during study period consists of 5 major classes and further divided into 13 subclasses. The major LULC class during the study period was agricultural land followed by waterbodies, forest area, wastelands and built up area. In the sub classes of agricultural land, agricultural land-crop land-kharif crop was increased by 557.13 acres (96.81%) from 18.33acres to 575.46 acres followed by agricultural land-plantation increased by 78.15 acres (16.30%) from 41.37 acres to 479.53 acres, agricultural land-fallow is increased by 40.38 acres (11.72%) from 304.27 acres to 344.65 acres while agricultural land-crop land-cropped in 2 Seasons was decreased by 970.41 acres (51.41%) from 1887.55 acres to 917.14 acres. the subclass agricultural land-crop land-rabi crop emerged as a new class in 2020-21 respectively. In the subclasses of waterbodies, the waterbodies- reservoir/tanks-permanent was increased by 136 acres (95.78%) from 5.99 acres to 141.98 acres and waterbodies-reservoir/tanks-seasonal increased by 5.07 acres (1.05%) from 478.79 acres to 483.86 acres. In the forest class, forest-scrub forest was increased by 33.59 acres (5.75%) from 551.01 acres to 584.60 acres while forest-forest plantation slightly decreased changes with 0.19%. The wasteland class with 2 sub-classes, in which wastelands-scrub land-open scrub was decreased by 107.31 acres (63.62%) from 168.68 acres to 61.36 acres followed by wastelands- gullied/ravenous land-gullied to the extent of 24.60 acres (40.02%) from 61.48 acres to 36.88 acres. In the built-up area class, built up- quarry was decreased by 1.62 acres (11.55%) from 14.07 acres to 12.44 acres followed by built up (rural) slightly decreased by 0.19% from 2010-11 to 2020-21 respectively.

Remote sensing and Geo-spatial technologies can be used to a large extent in watershed management. Water resource management should effectively be done by government with stringent rules. In the study, it is observed that wasteland in the Mukundaraju Cheruvu catchment area is gradually being converted into agricultural land and waterbodies. This can be avoided by wasteland reclamation with plantation programs. In the study area, Siltation process has been noticed. Timely de-siltation is essential to maintain original water holding capacity of the study area.

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