A STUDY ON IDENTIFICATION OF LANDSLIDE ZONES ALONG THE RECENT EXPANSION OF GVMC, VISAKHAPATNAM DISTRICT-A GIS APPROACH

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Abstract: The Greater Visakhapatnam Municipal Corporation (GVMC) city forms the area of the study in the present investigation. The population in the city is increasing at a rapid pace due to migration from surrounding areas, with corresponding increase in sub-urban areas also. The extensive growth of residential apartments along the coastal stretch resulted in excess withdrawal of groundwater initiating seawater intrusion in these tracts. All these factors combined, leading to an acute environmental crisis in the area. Forecasting urban water demand can be of use in the management of water utilities (Salvatore Campisi-Pinto, 2012).Hence, it is necessary to manage the available water resources in an efficient manner. This is done using advanced technologies like Remote Sensing and Geographical Information System. the sites for water harvesting structures and techniques like check dams, percolation ponds, infiltration wells, afforestation, contour trenching etc., previous literature gives us the techniques of image interpretation, concepts of remote sensing which help in identifying different features in the study area. Papers related to Geographic Information System tell us about the concepts of GIS which help in overlaying different layers for selecting the harvesting structures.

Keywords: LANDSLIDE ZONES, GVMC, R.S and GIS, INVESTIGATION

I. INTRODUCTION

Water being one of the most important natural resources need to be conserved and managed properly. As water covers 71 percent of the Earth's surface only three percent is fresh water and the rest 97 percent of the water on the Earth is salt water. 0.687 percent of total water resources are available as

ground water by the year 2005. Owing to industrialization and urbanization Indian metropolitan cities, were constructed unscientifically leading to irrational urban planning. Unless the need for scientific planning is realized, it is sure to clear up the environment. In coastal cities like Visakhapatnam, another major problem is seawater intrusion. As the seawater moves, inland groundwater aquifers become contaminated with salts, which may cause permanent damage to the aquifer.

The Greater Visakhapatnam Municipal Corporation (GVMC) city forms the area of the study in the present investigation. The population in the city is increasing at a rapid pace due to migration from surrounding areas, with corresponding increase in sub-urban areas also. The extensive growth of residential apartments along the coastal stretch resulted in excess withdrawal of groundwater initiating seawater intrusion in these tracts. All these factors combined, leading to an acute environmental crisis in the area. Forecasting urban water demand can be of use in the management of water utilities (Salvatore Campisi-Pinto, 2012).Hence, it is necessary to manage the available water resources in an efficient manner. This is done using advanced technologies like Remote Sensing and Geographical Information System.

Location of the Study Area

The study area the Greater Visakhapatnam Municipal Corporation (GVMC) is located between $17^{0}32^{1}30^{11}$ - $17^{0}52^{1}30^{11}$ northern latitude and $83^{0}04^{1}30^{11}$ - $83^{0}24^{1}30^{11}$ eastern longitude. The urban area of GVMC is divided into six zones. These six zones are further divided into 72. Municipal wards covering a total area of $545km^{2}$. The city is bounded by Bay of Bengal on eastern side, Duvvada hills, (Adavivaram hills) on the western side, Yarada konda on the southern side and Madhurawada dome on the north side Fig.1.

The study area is one of the major municipal corporations in the state of Andhra Pradesh. The area is famous for industries and tourism; often it is called as industrial city or city of destiny. The area has the reserved forests within the jurisdiction of GVMC. Due to recent developments such as IT Park and other constructions have come up in thick vegetated hilly area resulted in reduction of reduced forest cover. The area is well connected by rail, road, air and water (sea). According to 2001 census, the area has 1.7million population. High density population is located in the vicinity of GVMC area. The fringe area has very low density population where as areas like chinthala Agraharam, Adavivaram, Gambhiram appears to be rural. Extensive agriculture is the major land use in these villages.

The area has more number of major industries such as Visakha Steel Plant, BHPV, Zinc smelter etc. The GVMC is not able to provide sufficient water to all industries. The situation is more precarious during summer period. Visakha Steel Plant is having its own source of water supply whereas other industries are depending on GVMC water supply. Presently, GVMC is drawing water from Mudasarlova, Meghadrigedda, Gambhiram, Thatipudi and Raiwada reservoirs. Majority reservoirs have been silted up above its dead storage (Jagadheeswara Rao,2011) capacity resulting in less storage in reservoir. Water demand is increasing year after year which is leading to severe water crisis. To address this problem the present topic has been selected to augment ground water levels by adopting artificial recharge techniques in the study area. The study has been carried out with the following objectives.

Objectives of the study Area:

The study has been carried out with the following main objectives for ground water resource management in GVMC area

- To quantify the ground water scenario in GVMC area.
- To study the feasibility for implementation of artificial recharge structures.
- To study the suitable sites for the construction of check dams and percolation tanks.

- To extract automated built-up area from Normalised Differential Building Index (NDBI).
- To study Land Use/ Land Cover pattern for better understanding of the study area.

Data used

In this study, the following data have been used for ground water resources management

- The study area is covered in 65O / 1, 2, 4 & 6 of Survey of India toposheets on 1:50,000 scale.
- Google Earth image of the study area is downloaded in the Elshayal Smart Web Online Solutions open source software with an elevation of 500m.
- LANDSAT 8 image of the study area is downloaded from the website United States Geological Survey.
- Population for the years 2021 and 2031 is calculated.
- Dug and bore well distribution data collected from GVMC.
- Agriculture data collected from Statistical Abstract of Visakhapatnam District, 2012-13.

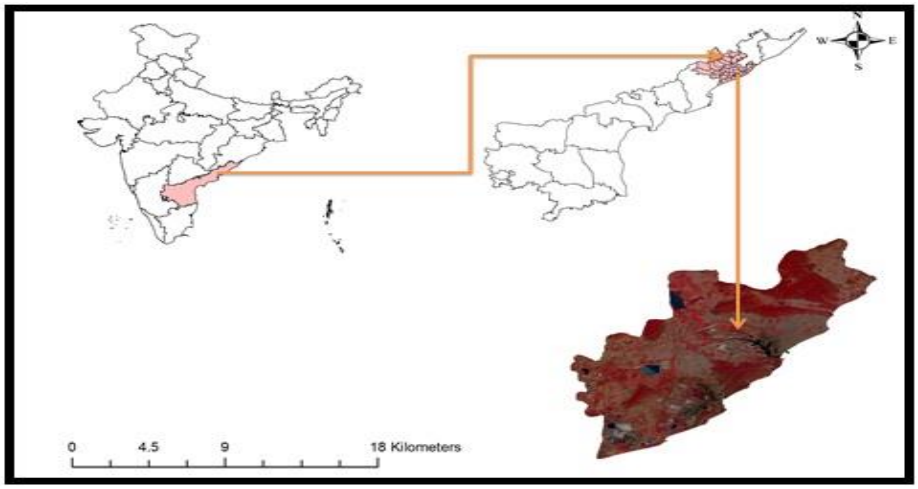

Figure 1: Location Map of the Study Area

The study area is one of the major municipal corporations in the state of Andhra Pradesh. The area is famous for industries and tourism; often it is called as industrial city or city of destiny. The area has the reserved forests within the jurisdiction of GVMC. Due to recent developments such as IT Park and other constructions have come up in thick vegetated hilly area resulted in reduction of reduced forest cover. The area is well connected by rail, road, air and water (sea). According to 2001 census, the area has 1.7million population. High density population is located in the vicinity of GVMC area. The fringe area has very low density population where as areas like chinthala Agraharam, Adavivaram, Gambhiram appears to be rural. Extensive agriculture is the major land use in these villages. The area has more number of major industries such as Visakha Steel Plant, BHPV, Zinc smelter etc. The GVMC is not able

to provide sufficient water to all industries.The study area is divided into 6 zones from the administrative point of view Fig.2. Further, these six zones are divided into 72 municipal wards.

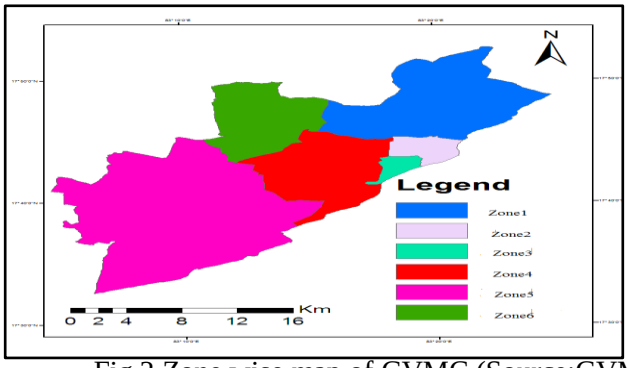

Fig.2 Zone wise map of GVMC (Source:GVMC, Visakhapatnam)

REVIEW OF LITERATURE

Li Xiaoyan1 et al., (2002) made a study on "Effects of Rainwater Harvesting on the Regional Development and Environmental Conservation in the Semiarid Loess Region of Northwest China". This study deals with the major environmental issues in the Loess Plateau and evaluates the influence of rainwater harvesting implemented since 1980s on the regional development and environment conservation. Based on the experiment on rainfall harvesting and field investigation, micro catchment model for ecosystem construction was proposed to improve regional environment. The micro catchment rainfall-harvesting model with small watershed as a unit is characterized by incorporation of rainfall harvesting with yard economy and environmental construction. ≥25° sloping land is protected as water conservancy zone by prevent human and livestock interference; tree (or shrub) and grass can be planted in the gentle slope by means of micro catchment water harvesting techniques. The natural slope can also be treated as catchment for collecting runoff into the cistern for supplemental irrigation for farmland, which is the main part of the system for supply food to farmer by various water-saving agriculture techniques.

Ranzi, et al., (2002) made a study on "Effects on floods of recent afforestation and urbanisation in the Mella River (Italian Alps)". This study involves is to quantify the effects of the urbanisation on the flood volumes and peaks in the Mella river basin, 311 km² in size, changes in land use in the past 50 years have been compared using two land use maps. The comparison showed an increase in the forested areas in the upper part of the basin as the use of wood for fuel had declined and an increase in urban development in the valley bottom. Land use has been changing in the Mella River since 1954. Forested areas increased (+15.1 km², +9%) as did urban areas (+12.1 km², +25.2%) while crops and pasture areas decreased and the capabilities of forests to store more water, as interception or in the soils rich in organic matter.

Girish Kumar, et al., (2002) made a study on "Delineation of Potential Sites for Water Harvesting Structures Using Remote Sensing and GIS" In the present study, potential sites for construction of rainwater harvesting structures in the Bakhar watershed of Mirzapur District,

Methodology

Maps have been used for better administration, revenue collection, etc. for thousands of years. But it is only within the last few decades that the technology has existed to combine maps with computer graphics and databases to create Geographic Information Systems or GIS The themes in the above graphic are only a small example of the wide array of information that can view In this chapter, information about

the need of the study, objectives of the study, location of study area, physiography, temperature, rainfall, vegetation, climate, demography, etc., are dealt. The overall process is represented in a flowchart.

Review of Literature chapter describes about papers related to methods for the selection of suitable sites for water harvesting structures and extraction of built-up land. The project related literature both from international and national is summarised in order to strengthen the methodology and other procedure.

Remote Sensing and GIS

Remote Sensing and GIS chapter deals about the basic concepts of remote sensing and GIS. Extraction of study area‟s LANDSAT-8 data and Google Earth‟s data is explained. Preparation of land use/ land cover data and automated extraction of built-up area using Normalized Differential Built-up Index (NDBI) algorithm for the study area is also explained.

Water Resource Management

Water resource management chapter deals with quantification of ground water. Different methods are suggested for water harvesting and suitable sites are selected for water harvesting structures like contour trenching,check dams, percolation ponds, infiltration wells and afforestation on the basis of different terrain characteristics.

Irrigation and Cropping Pattern

Built-up is the major land use in Greater Visakhapatnam Municipal Corporation, However, a limited cultivation is noticed in the sub urban areas. Water supplied for irrigation is from Meghadhrigedda, Gambhiram reservoir. A less is available for agricultural in zone5 and zone 6 and these agricultural fields are irrigated by nearby water bodies. Paddy is the major food crop during Kharif season. Pulses and vegetables are the major crops in other season .

Majority agricultural lands are converting into urban layouts. However, cultivating Paddy and Vegetables in Chintala Agraharam, Gambhiram and Pinagadi villages. Agricultural areas were identified on satellite image pale red tone with irregular shape.

I. INTEGRATION OF THEMATIC LAYERS:

In this study, geology, soil, geomorphology, land use/land cover and slope thematic layers have been used in GIS analysis. Toposheets have been used for digitization of drainage pattern of the area Onscreen digitization has been carried out and assigned stream orders.

Data Used

The following data have been used in this study. The details of which is given in Table 1

- LANDSAT 8 image
- Google Earth image
- SOI Toposheets

Table 1 Details of Landsat-8 image

Name of the satellite	Row	Path	Sensor	Date of acquired
Landsat-8	48	141	OLI,TIRS	13-3-2015

LANDSAT 8 image

LANDSAT 8 image for GVMC area is downloaded from the United States Geological Survey website. The path and row of the image are 141 and 48 respectively. The sensors of LANDSAT 8 image are panchromatic, multispectral and thermal with the resolution of 15, 30 and 100 metres. The map projection is UTM and the study area falls under the zone 44. The LANDSAT 8 satellite consists of image has 11 bands. The list of bands in LANDSAT 8 image is given Table 2.

Table 2 Band width and resolution of all the bands of LANDSAT-8 image

Band Number	Band width (µm)	Resolution(m)
Band1 Coastal	0.433–0.453	30 m
Band 2 Blue	0.450–0.515	30 m
Band 3 Green	0.525–0.600	30 m
Band 4 Red	0.630–0.680	30 m
Band 5 NIR	0.845–0.885	30 m
Band 6 SWIR1	1.560–1.660	30 m
Band 7 SWIR2	2.100–2.300	30 m
Band 8 Pan	0.500–0.680	15 m
Band 9 Cirrus	1.360–1.390	30 m
Band 10 TIRS1	10.6-11.2	100 m
Band 11 TIRS2	11.5-12.5	100 m

Composite Bands

A composite band is the process to combine the required bands of the satellite image. The composite band tool is present in a set of raster processing tools in raster tools in data management tools. The following bands are combined for the present study Table 3.

Table 3 Band width and resolution of selected bands of LANDSAT-8 image

Band Number	Band width (µm)	Resolution(m)
Band 1 Blue	0.450–0.515	30 m
Band 2 Green	0.525–0.600	30 m
Band 3 Red	0.630–0.680	30 m
Band 4 NIR	0.845–0.885	30 m
Band 5 SWIR1	1.560–1.660	30 m
Band 6 SWIR2	2.100–2.300	30 m

Extraction by mask

The LANDSAT-8 image downloaded and layer stacked consists of whole Visakhapatnam district. To get the image consisting only the Greater Visakhapatnam Municipal Corporation area, that particular area is to be extracted. Extraction should be done by overlaying the boundary of the study area. The following are the steps involved in the process of extraction.

- Open the layer stacked image and boundary of the GVMC area.

- Open Arc tool box.
- Click on spatial analyst tools.
- Click on extraction by mask.
- Give the satellite image and boundary respectively in the window opened.
- Save the output in the required folder.

A single model for atmospheric correction, composite bands and extraction by mask is written in model builder window in Arc GIS 10.2.

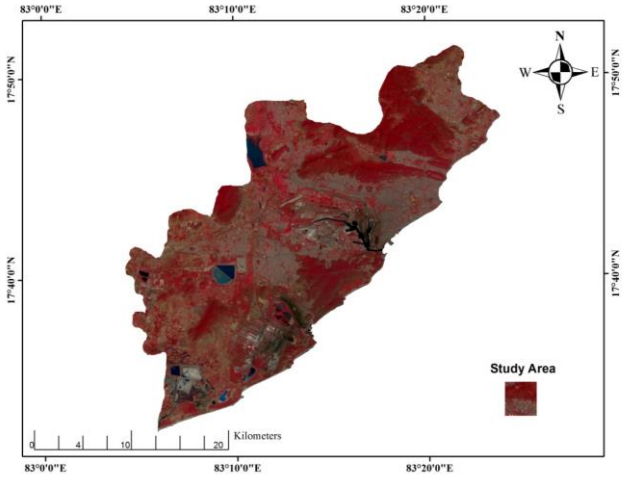

Figure 3: LANDSAT-8 image

Land Use / Land Cover Studies

Land Use / Land Cover information is the basic requisite for land, water and vegetation resources utilization, conservation and measurement. Land use describes how a piece of land is used, such as for agriculture or industry, whereas land cover describes the materials, such as vegetation, rocks or buildings that are present on the surface. Land use / land cover features to some extent reflect the geological / geomorphological controls.

Interpretation of satellite imagery (GOOGLE EARTH and LANDSAT-8-OLI, path 141 and row 48 dated 13th March, 2015), coupled with thematic maps has helped in mapping the various land use / land cover features in the (GVMC). A review of the major land use / land cover features of the city area is described below.

Significance of Information on Land Use / Land Cover

Information on existing land use / land cover and pattern of their spatial distribution forms the basis for any development planning. The current land use need to be assessed for its suitability in the light of the land potential before suggestion alternate land use practices. The land cover maps derived by remote sensing are the basis to know the hydrological response units in the area. In order to have a better understanding of the hydrology of the area with little available data, a better insight into the distribution of the physical characteristics of the catchment areas is needed. By

image processing techniques, image can be produced which depict some of the characteristics, primarily the cover types such as areas with vegetation, water bodies, areas with bare soils or out crops and settlement areas etc. land use pattern of any watershed influences the runoff and evapotranspiration.

Land Use / Land Cover Categories

Classification of the land use / land cover types as per NRSC specifications is presented in Table 4.3. This is a modified version of the land use / land cover classification suggested by Anderson (1965).

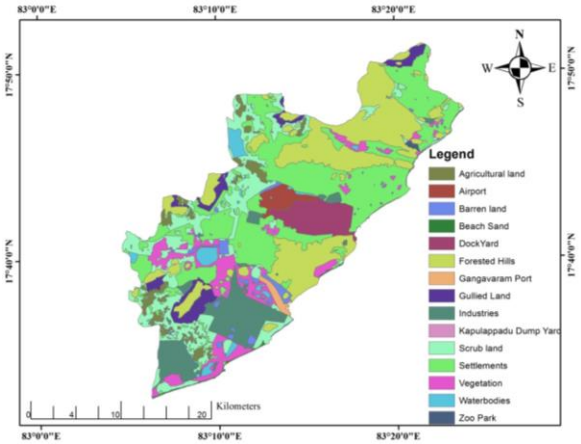

Fig.4 Land Use/ Land Cover of the study area

Built up land

It is an area of human habitation developed because of non-agricultural use of the land and it has a cover of buildings, transport and communication utilities in association with water, vegetation and vacant lands. In the present study area, the built-up land cover comprises of mostly GVMC area and other important villages / area are Gopalapatnam, Gajuwaka, Malkapuram, MVP colony, Isakathota, Venkojipalem, Mindhi, Scindia, NAD junction, Industrial area, RTC complex, Jagadamba junction, old post office etc.

a) Built-up land (High / Medium density)

This is basically a residential, commercial and Industrial areas under GVMC and come in this category.

b) Built-up land (planned residential area)

All the recently developed residential areas come under this category.

Examples are M.V.P. colony, Sithammadhara, Muralinagar and Dwarakanagar etc. All these areas were developed by VUDA. The built-up area is identified on the satellite image with the cyan colour and medium texture. All these are connected by road network. MVP colony is one of the biggest residential colony in Asia 4.

c) Built-up land with vegetation and sub-urban area

In this category, the areas which are properly planned with plantation cover are considered. It comprises of some parts of the city, rural areas of GVMC such as Narava, Sheelanagar, Pendhurthi, Kommadi, Adavivaram etc. And also areas under construction, upland areas like Waltair uplands, Dasapalla hills, slope areas like Railway yard, Port and

Soil map

Soil map is a geographical representation showing diversity of soil types and soil properties. Soil maps are most commonly used for land evaluation, traditional soil maps typically show only general distribution of soils. Generally soil maps are used to simply identify soils and their properties, but sometimes required for more specific purposes, such as determining the suitability of a soil for particular crops, harvesting structures and land drainage capabilities of an area.

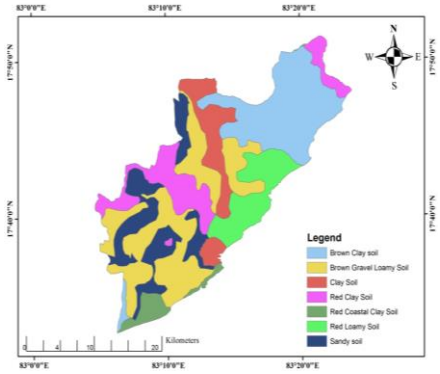

Fig.5 soil map of the study area

Soil map of GVMC area consists of different soils namely Brown clay soil, Brown gravel clay soil, Brown gravel loamy soil, Clay soil, Red clay soil, Red coastal clay soil, Red loamy soil and Sandy soil fig.5. Selection of soil type is based on the type of harvesting structure technique is taken. Brown clay soil is covered in mostly Visakhapatnam rural mandal areas like Madhurwada, Kommadhi and some part in Peddha gantyada mandal. Similarly Brown gravel clay soils is covered areas like NAD, Narava, Steel Plant and some places in Peddha gantyada mandal. Brown gravel loamy soil is covered only besides the Meghadrigedda. Clay soil is covering areas of Gopalapatnam, NAD, Sheelanagar. Red loamy soil is covering industrial area and sandy soil is present near Meghadrigedda and some places in Peddha gantyada mandal and Gajuwaka mandal.

Different artificial recharge techniques have been selected based on soil, slope, drainage and other properties. Mostly loamy type soil has been chosen for artificial recharge techniques. High clay content soils were rejected due to impermeability.

Slope map

Slope map shows the elevation of the particular area. The steepness value is bounded between maximum and minimum values. The slope of elevation can be depicted in two ways one is in degree and another in percent wise. The generation of slope map includes the following procedure.

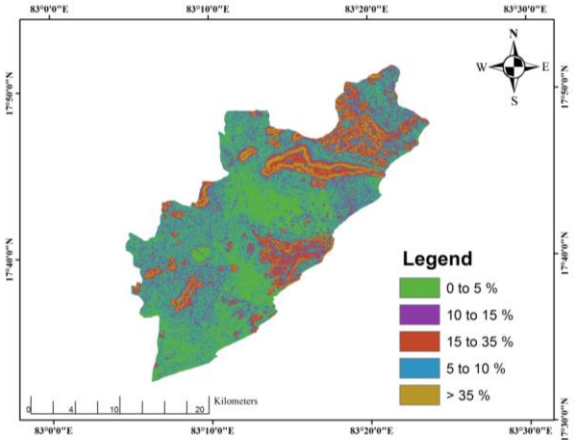

Fig 6: slop map of the study area

Geomorphology:

The study is focused light on sediment deposition in the landslide vulnerable zones along the Bhimili road. Geomorphology of the area has been delineated on LANDSAT-8 satellite data. In this 13 fluvial and erosional classes were identified in which six are run-off zones and rest is infiltration zones. Run-off zones contribute sediment to the plains. Thus surface water bodies in the area have been highly silted up [9].In GIS analysis, six classes have been considered to locate landslide vulnerable zones in the area. The following weight classes assigned to the geomorphic classes.

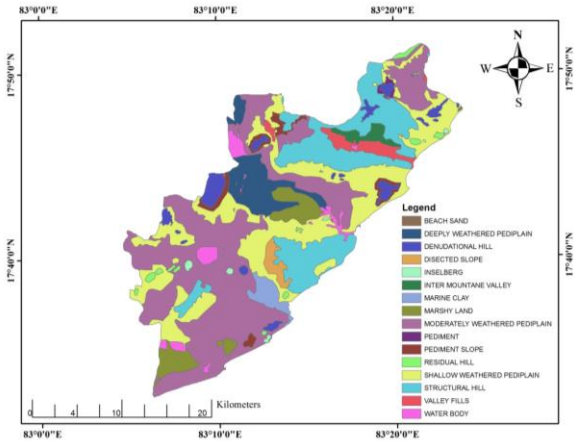

Figure 7: geomorphology map of the study area

Geology

Geology map has been generated using the GSI Greater Visakhapatnam Municipal Corporation (GVMC) Visakhapatnam District. Three major rock types are exposed in the area, out of which khondalite is the major rock type followed by Charnockite and quartzite. Charnockite and quartzite occur as intrusive bodies into the country rock. The weight classes were assigned on the basis of rock type

which in turn its ease to weathering cohesiveness and erosion. The following weight classes assigned to the rock types in which khondalite country rock is considered in the GIS analysis.

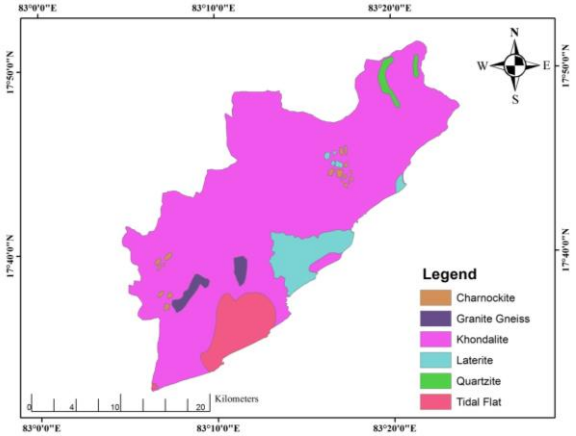

Figure 8: geology map of the study area

Drainage map

Drainage map has been generated using the GSI Greater Visakhapatnam Municipal Corporation (GVMC) Visakhapatnam District. Drainage Area. The term "drainage area" is defined as the land area where precipitation falls off into creeks, streams, rivers, lakes, and reservoirs. It is a land feature that can be identified by tracing a line the highest elevation between two areas on a map, often a ridge.1 to 5 orders streams.

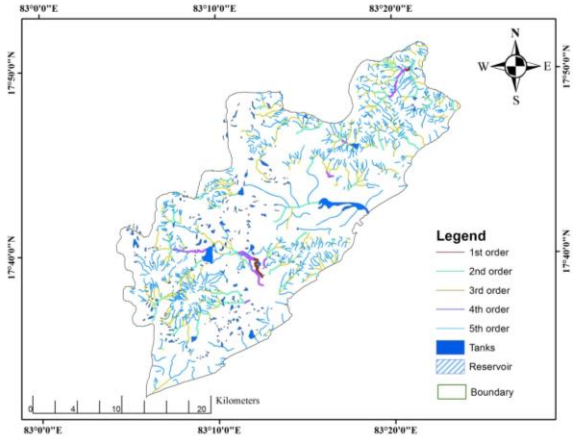

Fig 9 Drainage map of the study area

SUMMARY AND CONCLUSIONS

This includes the information in earlier chapters like introduction, review of literature, remote sensing and GIS and methodology (calculation of water demand for present population and industrial, water demand in future for years 2021&2031, selecting appropriate sites for harvesting structures to meet the demand of water)for the Greater Visakhapatnam Municipal Corporation study area.Review of literature chapter describes about selecting the sites for water harvesting structures and techniques like check dams, percolation ponds, infiltration wells, afforestation, contour trenching etc., previous literature gives us the techniques of image interpretation, concepts of remote sensing which help in identifying different features in the study area. Papers related to Geographic Information System

tell us about the concepts of GIS which help in overlaying different layers for selecting the harvesting structures.

In this chapter the supply and demand of water details are discussed and the deficit is calculated. Also the suitable sites for water harvesting structures are selected. They are listed below

- The demand of water in study area is 57.09 MGD.
- Water supply for the domestic purpose is 49.46 MGD.
- Deficit of water for domestic purpose is 7.632 MGD.
- Water supplied for industrial purpose is 17.97 MGD.
- Demand for industrial purpose is 19.16 MGD.
- Deficit of water for industrial purpose is 1.98 MGD.
- Total deficit is 8.822MGD.
- The demand of water will be 91.86MGD for population 2784171 in year 2021.
- The demand of water will be 151.154MGD for population 4581075 in year 2031.
- Importance and need of water harvesting methods is discussed.
- Rain water harvesting structures are suggested to store water and increase the water levels in GVMC area
- Desiltation of tanks are suggested for main tanks like KBR and Mudasarlova tanks
- Sites for check dams are suggested.4 check dams are suggested
- 2 Sites for percolation ponds are suggested.
- 10 infiltration wells are also be suggested all over the study area
- Contour trenching technique is also suggested for the hill forests in GVMC area
- Afforestation in suggested in some areas of study area and the total area suggested for afforestation is 2479.88ha

REFERENCES

1. Ratnakar Dhakate & Gurunadha Rao .V. V. S,. Anandagajapathi Raju.B, Mahesh.J,Mallikharjuna Rao .S. T & Sankaran. S 2012. Integrated Approach for Identifying Suitable Sites for Rainwater Harvesting Structures for Groundwater Augmentation in Basaltic Terrain.
2. Yogesh Bamne1, Patil2. Dr. K. A, Vikhe. S. D 2014. Selection of Appropriate Sites for Structures of Water Harvesting in a Watershed using Remote Sensing and Geographical Information System International Journal of Emerging Technology and Advanced Engineering. ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 4.
3. Singh.P.J, Darshdeep singh, Litoria .P.K 2009. selection of suitable sites for water harvesting structures in soankhad watershed, punjab using Remote sensing and Geographical information system (RS & GIS) Approach- a case study Research article

4. Harish Chand Prasad, Parul Bhalla and Sarvesh Palria 2014. Site Suitability Analysis of Water Harvesting Structures Using Remote Sensing and GIS – A Case Study of Pisangan Watershed, Ajmer District, Rajasthan The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-8

5. Deivalatha.A, Senthikumaran.P and K.Ambujam.N 2014. Impact of desiting of irrigation tanks on productivity of crop yield and profitability of farm income African journal of agricultural research
6. Jasrotia.A.S. (2008) .Water Balance Approach for Rainwater Harvesting using Remote Sensing and GIS Techniques, Jammu Himalaya, India.
7. Hanqiu Xu., 2007. Extraction of Urban Built-up Land Features from Landsat Imagery Using a Thematicoriented Index Combination Technique Photogrammetric Engineering & Remote Sensing Vol. 73, No. 12, pp. 1381–1391.
8. Hordur V. Haraldsson, Harald U. Sverdrup, Salim Belyazid, Bjarni D. Sigurdsson AND Guomundur halldorsson 2007. Assessment of effects of afforestation on soil properties in Iceland, using Systems Analysis and System Dynamic methods
9. Li Xiaoyan, Zhang Ruiling, Gong Jiadong and Xie Zhongkui 2002 Effects of Rainwater Harvesting on the Regional Development and Environmental Conservation in the Semiarid Loess Region of Northwest China
10. Ranzi.R, Bochicchio.M and Bacchi.B 2002. Effects on floods of recent afforestation and urbanisation in the Mella River (Italian Alps) Hydrology and Earth System Sciences
11. Girish kumar. M, K. Agarwal. A, Rameshwar Bali 2008. Delineation of potential sites for water harvesting structures using Remote Sensing and Geographical Information System Journal of the indian society of remote sensing
12. B. Balakrishna. H, C. Jayaramu.K 2014. Identification of Potential Sites for Rainwater Harvesting using Remote Sensing and Geographical Information System
13. Lejiang Guo,Lei Xiao Lejiang Guo,Lei Xiao Hu 2010. Application of GIS and Remote Sensing Techniques for Water Resources Management, 2nd Conference on Environmental Science and Information Application Technology.