# APPLICATIONS OF REMOTE SENSING AND BEST MANAGEMENT PRACTISE METHODS FOR FLOOD CONTROL MANAGEMENT IN FLOOD PRONEAREAS OF VIJAYAWADA

A Project submitted to

**JNTU KAKINADA UNIVERSITY**

In the partial fulfilment of the Requirements for

the award degree.

**BACHELOR OF TECHNOLOGY**

**IN**

**CIVIL ENGINEERING**

Submitted by


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**Ganguru, Vijayawada-521139**


**2019-20.**

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**Accredited by NAAC**

# CERTIFICATE

This is to certify that the project entitled "**APPLICATIONS OF REMOTE SENSING AND BEST MANAGEMENT PRACTISE METHODS FOR FLOOD CONTROL MANAGEMENT IN FLOOD PRONE AREAS OF VIJAYAWADA**" is being submitted by

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In partial fulfilment for the award of the "**Degree in Bachelor of Technology"** in Civil Engineering to the Jawaharlal Nehru Technological University Kakinada is a record of bonafide work carried out under my guidance and supervision.

The results embodied in this project report have not been submitted to any other University or Institute for the award of any Degree or Diploma.

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**THIS PROJECT WORK IS APPROVED BY THE FOLLOWING BOARD OF EXAMINERS**

1. **EXTERNAL EXAMINER:**

**2 .INTERNAL EXAMINER:**

# DECLARATION

The project entitled **"APPLICATIONS OF REMOTE SENSING AND BEST MANAGEMENT PRACTISE METHODS FOR FLOOD CONTROL MANAGEMENT IN FLOOD PRONE AREAS OF VIJAYAWADA"** is solely carried by us and we declare that the embodied results in this project is genuine work and has not been submitted either to University or any Institute.

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# CHAPTERS

# APPENDIX

## Vision, Mission of the Department & Institute

**Institute Vision:-**

- Pioneering Professional Education through Quality.

**Institute Mission:-**

- Providing Quality Education through State of Art Infrastructure, Laboratories and Committed Staff.
- Moulding Students as Proficient, Competent and Social Responsible Engineering personnel with ingenious Intellect.
- Involving Faculty Members and Students in Research & Development works for betterment of Society.

**Department Vision:-**

- To become a pioneering centre of learning and research in Civil Engineering.

**Department Mission:-**

- Providing high Quality Education in atmosphere and Innovation and Critical Thinking.
- An integrated Development of Civil Engineering Professionals possessing technical and Management Skills, Environmental, ethical and Human Values.
- Inculcating research and Consultancy Culture by involving Faculty and Students.

**Programme outcomes: -** Engineering Graduates will be able to

- <u>Engineering Knowledge</u>: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- <u>Problem analysis:</u> Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural science, and engineering sciences.
- <u>Design/development of solutions:</u> Design solutions for complex engineering problems and design system components or process that meet the specified needs with appropriate considerations for the public health and safety, and the cultural, societal, and environmental considerations.

- Conduct investigations of complex problems: Use research- based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- Modern tool usage: create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of limitations.
- The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge and need for sustainable development.
- Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

**TITLE vs. PO MAPPING**

| PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 2 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 3 |

**Program Specific Outcomes**

PSO1: knowledge of contemporary issues in the civil engineering industry to solve societal issues.

PSO2: Qualify in competitive examinations for higher education and employment.

**TITLE VS PSO MAPPING**

| PSO1 | PSO2 |
|---|---|
| 3 | 2 |

**Justification of PO and PSO mapping: -**

- The title is mapped high for the PO 1,2,3,4,6,9,12 as the Engineering knowledge is essential for design and analysis .
- The title is mapped moderately for the PO 5, 7, 10, 11 as the modern tool usage, environmental context, communication and project management is necessary to complete the project.
- The title is mapped low for the PO 8 as professional ethics is also required up to some extent for successful completion of the project.
- The title is mapped high for the PSO 1 as this knowledge of design and analysis of gravity dam helps to solve the contemporary issues in society.
- The title is mapped moderate for the PSO 2 as this knowledge is used in the qualifying higher education and employment.

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## ABSTRACT

A flood is an overflow of water that submerges land when severe rainfall occurs. The flooding may occur as an over flow of water by heavy rainfall/snow storms/ water bodies such as rivers or lakes in which the water overtops and may result in some of that water escaping its usual boundaries. Floods cause severe damage to the infrastructure and human beings, if they occur in upslope areas and as catastrophic events. Some floods develop slowly, while others can occur in just a few minutes. Additionally, floods can be local, imparting a neighborhood or community, or very large, affecting entire river basin. However, the most affected areas by the floods are urban areas because of rapid urbanization. Floods in the urban areas can be controlled by using the best management practices (BMP'S), since they are highly effective and economic approaches to control the damages occurring by floods in urban areas. Hence a study is carried in Vijayawada, which is a major town of Andhra Pradesh after bifurcation. For the same, we utilized remote sensing and GIS datasets to find out the inundation zones and thus explored the suitable BMP'S to mitigate the flood. Among all the methods, the with moderate porosity characteristics are highly recommended for this region to avoid the floods



**Key Words: -** Urbanization, BMP'S, Remote sensing data, Porosity.

# CHAPTER 1

# INTRODUCTION

When inflow exceeds outflow in a low-lying areas, then it is termed as flood. Normally flood occurs when there is a heavy rainfall, or with seepage problem when rapid concretization occurs. Mostly floods occur in low-lying areas and in high urban areas having huge population density. Most of the flood prone regions are Hyderabad, Bangalore, and Chennai, and the coastal areas like Kerala, Mumbai and Goa. These places are highly urbanized and concretized due to ongoing increase in population. Hence flood management practices are highly essential in the ongoing construction areas under the ongoing climatic changes scenarios of 21st century. Floods also leads to the damage of several infrastructure and human beings.

For example, let us consider few case studies carried on floods occurred in India since past three to four decades. Floods have been occurred in several places in India, However, most dangerous one was occurred in the year 1987 were approximately 14000 people and 5300 animals were died and almost 29 million people's infrastructure and lives were under threat. Another flood was occurred in Andhra Pradesh, in 1990 where almost 967 people were died and 27000 people are caught in inundation zones, with an average effected paddy fields of 4,35,000 acres. In 2005 floods occur in Gujarat which leads to the death of 130 people and a great financial and economic loss up to 80 million rupees. A month after the Gujarat floods, the same situation occurred in the Maharashtra in which 50 local trains, 35,000 autos, 4000 people were affected. Again the Bihar faces the disaster of flood in 2007 and 2008, almost 2.3 million were affected in which 250 people lost their lives. In 2009, Krishna River overflows causing the flood in Andhra Pradesh. A huge loss was occurred in Krishna and Guntur districts which consists of 478 villages and 87 mandalas. It is recoded as the deadliest flood in past 100years in which 13 lakh people affected. Assam heaviest flood occur in 2012 due to Brahmaputra River excess flow. Nearly 70,000 hectares of cropland was affected and 130 members lost their lives. Uttarakhand floods were occurred in 2013 in which 1,00,000 pilgrims were trapped and almost 500 people were died. Jammu & Kashmir floods were occurred by the torrential rainfall in which 390 villages were completely submerged. 2015 is the darkest year of India because three states i.e.; Assam, Gujarat, Chennai faced the flood situation. In this disaster around 1000 people were killed and 2.3 million people were displaced. Same situation occurred after a year i.e; 2017, Bihar, West Bengal, Mumbai. Due to the Himalayan river Gandak Bihar flood was occurred and it takes the lives of 514 people. Due to the Komen cyclone West Bengal floods were occurred and it also affects the neighbouring state Jharkhand. Mumbai floods occurred in the times of august which affects the transportation system hugely. One of the biggest disaster occurred in 2018 in Kerala, around 37,000 people were under the life threat and almost 470 people were killed. Again Andhra Pradesh faced the disaster due to flood in 2019, both Krishna and Guntur districts were affected by this, more than 17,400 people were killed, 11,400 were to other places by the 56 relief camps and provided with basic needs.

Hence, there exists an emergency to estimate flood prone areas. In the past years the flood inundation is carried by traditional techniques like mapping, commercial surveys and by using the Past data. Now it became easy to assess the flood inundation areas by RS and GIS techniques which use the spatial data. Thus, this study utilized RS & GIS techniques for estimation of the flood inundation areas (reference). We can assess them by collecting different layers of spatial data such as watershed characteristics, land use land cover, drainage pattern, soil characteristics, rainfall intensity, urbanization etc. After assessment, the flood prone will be assessed further to identify the best management practices to carry the execution of flood reduction plans.

## 1.1 PROBLEM IDENTIFIED: -

The primary goal of this project is to find out the flood inundation zones and to identify the best BMP design to reduce runoff volume by infiltrating rainfall water to ground water, evaporating rain water back to the atmosphere after storm and find the beneficial uses rather than passing them in to streams as a waste product.

## 1.2 AIM: -

To implement BMP's for the flood prone areas in urban area (Krishna Lanka and Yenamalakudhuru) of Vijayawada.

## 1.3 OBJECTIVES: -

- To find out the inundation zones in the low laying urban areas of Vijayawada.
- To increase the ground water potential by enhancing the infiltration capability by permeable pavement in low-lying Vijayawada areas.

## 1.4 SCOPE: -

- To identify the flood prone areas using Remote sensing and GIS techniques.
- To trace flood prone areas in Vijayawada and its surrounding areas

## 1.5 EXPECTED OUTCOME: -

To reduce the flood in urban areas and to increase ground water level by natural recharge.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 The Vijayawada

The old name of Vijayawada is Bezawada. The name “Bezawada” is derived from “Bezzamwada” where in it ‘Bezzam’ means HOLE and ‘wada’ means a residential place in Telugu. As the time passed it became Bezawada. This name is obtained because once upon a time it is said that the river Krishna used to flow through just a small slit from the city, but later on it expanded and due to its aggressive flow the entire hill blocks of indrakeeladri (The holy temple hill) is divided into parts. So by the name of the slit that gives pass to the river Krishna the city name became Bezzamwada thereby Bezawada. And similarly Vijayawada is also an old name. It is said that the name is because Arjuna, one of the pandavas during the times of Mahabharata came to this place and worshipped lord Siva to get ‘Pasupathi asthra’. Arjuna is also known as ‘Vijaya’. Hence the name Vijayawada.

## 2.2 Physiography

**Vijayawada** (formerly known as **Bezawada**) is the 2nd largest city in the Indian State of Andhra Pradesh. It lies on the banks of River Krishna surrounded by the hills of Eastern Ghats known as **Indrakeeladri Hill** in Krishna District. It geographically lies on the centre spot of Andhra Pradesh. The city has been described as commercial, political, educational and media capital of Andhra Pradesh, also 42nd largest city in India and is one of the rapidly growing urban areas in India. It is considered to be a sacred place for residing one of the most visited and famous temples of Andhra Pradesh and India, Kanka Durga Temple of Hindu Goddess Durga. Its railway station stands as one of the ten busiest railway junctions in India. Vijayawada lies on the banks of Krishna River, covered by hills and canals. It is 18.5 km (11.5 mi) from the state capital, Amravati and at an altitude of 11 m (36ft.) above sea level. Three canals originating from the north side of the Prakasham barrage reservoir Eluru, Bandar, and Ryves flow through the city.

## 2.3 Climate

Vijayawada has a tropical climate. The annual mean temperatures range between 23.4–34 °C (74–93 °F); with the maximum temperatures often crosses 40 °C (104 °F) in the month of May and the minimum in December and January. The highest maximum temperature ever recorded was 48.8 °C (119.8 °F) in May 2002, and the lowest was 12.4 °C (54 °F) on January 1997. May is the hottest and January is the coldest month of the year. It receives rainfall from the South-west and North-east monsoons and the average annual rainfall recorded is 977.9 mm (38.50 in).

## 2.4 Krishna River System

The **Krishna River** is the fourth-biggest river in terms of water inflows and river basin area in India, after the Ganga, Godavari and Brahmaputra. The river is almost 1,400 kilometres (870 mi) long. The river is also called Krishnaveni. It is one of the major sources of irrigation for Maharashtra, Karnataka, and Telangana Andhra Pradesh. The Krishna River originates in the Western Ghats near Mahabaleshwar at an elevation of about 1,300 metres (4,300 ft.), in the state of Maharashtra in central India. The delta of this river is one of the most fertile regions in and was the home to ancient Satavahana and Ikshvaku Sun Dynasty kings. Vijayawada is the largest city on the Krishna. Krishna Basin extends over an area of 258,948 $km^2$ (99,980 sq. mi) which is nearly 8% of the total geographical area of the country. This large basin lies in the states of Karnataka (113,271 $km^2$), Telangana, Andhra Pradesh (76,252 $km^2$) and Maharashtra (69,425 $km^2$).

## 2.5 Low lying areas in Vijayawada

Namely Krishna Lanka, Ramalingeswara Nagar, Yanamalakuduru, Traka Rama Nagar, Ranigarithota, Balaji Nagar, Police Colony, Geetha Nagar, and Bhavanipuram (Lanchirevu) are the low laying areas of Vijayawada.

## 2.6 Case Studies

**2.6.1 PAUL D. BATES etc. (2012):** The article produced in hydrological process by bates in 2004 used remote sensing data which provided a way in flood inundation modelling. The only data available to build, parameterize, calibrate and validate hydraulic models were from limited ground topographic surveys and space ground gauging stations with spacing's of between 10 and 60km. the hydraulic models were carried in two main ways. First, the ground survey terrain data that were available were typically captured as a series of cross sections perpendicular to the channel and flood plain that were more easily integrated with one dimensional (1D) models. Second, the use of widely spaced point gauge data for calibration and validation meant that the only aspect of model performance that could be tested effectively was the ability of a model to route a wave in ID along a river network. The breakthrough came with the advent of remote sensing techniques for wide area topography mapping, principally using Air brone laser altimetry (LiDAR) which captured at approximately 2-5m spatial resolution at survey rates of up to 50$km^2$ and had a accuracy of approximately 10-15cm. LiDAR data is more transformative and raised the expectations that models built using them should be able to predict inundation extent accurately. Moreover it also contains vegetation height, which leads to determine the flood plain constrain friction parameters where vegetation drag is a major contributor to total frictional losses. Therefore a global DEM with decimetre vertical accuracy will also have been produced. Although the above issues require resolution, progress in developing very efficient hydraulic models and demonstrating that there are capture of representing detailed inundation patterns over large domains with high skill opens up several new research areas that hydrologists can start to take advantage of RS and GIS. By assimilating SWOT data with hydraulic models we may also be able to make estimates of bathymetry friction and discharge in un-gauged basin to achieve a consistent global view of terrestrial water storage change.

**2.6.2 Emin tas (2016):** He prepared the flood inundation maps using GIS and a hydraulic model (hec ras) in akarcay bolvadin sub basin of turkey. The akarcay basin (7605 $km^2$) is a closed watershed, in joint area of Aegean, Mediterranean and central Anatolia regions of turkey. During investigation, water levels are determined and submerged areas for various return periods by using GIS based hydraulic model. The required input TIN layer is prepared in GIS, which acted as base of hydraulic model (grid resolution: 10mx10m). Hec georas is a subprogram in ArcGIS that supplies transfer of required topographic and geometric data with GIS base into the model. Input data into the model can be manual, but using hec georas provides integration of GIS and hydraulic model. In the same breath, it is provided that input data into the model is quicker and more detailed. Required topographic and geometric data (stream centreline, bank lines, flow paths, cross sections, river reaches, junction point and tributary angle) for running model are obtained on tin data by hec georas and export file created to import into hec ras software. Flood flow data (recurrence intervals: 100 and 500 years) is calculated by fuller method. However, the hec ras application need in depth knowledge of basin characteristics.

**2.6.3 VAHDETTIN DEMIR etc. (2015):** Has made the Flood Hazard Maps using Geographic Information System and Hydraulic Model for Mert River basin. This area is chosen as study area because it is almost under threat of flooding in each year. In this region, the main reason of devastating flood is the influence of seasonal rainfall. In addition, the human based constructions and the collapse of water retaining structures are among them are the main causes of flooding. Geographic Information Systems (GIS) is successfully used to visualize the extent of flooding and also to analyse the flood maps to produce flood damage estimation maps and flood risk map in this study. First, 3D model of study area was prepared utilizing ArcGIS. Digital Elevation Model (DEM) was produced by 1/1000 scale topographical contour lines. Then, topographic data obtained from ArcGIS were transferred to HEC-RAS via Hec-Georas module. Flood values of different return periods (10, 25, 50, and 100 years) and Manning roughness coefficient values were also entered into the HEC-RAS program for calculating water level for each cross section. Finally, the hydraulic analysis results were entered into the ArcGIS via Hec-Georas module and flood hazard maps were obtained for each return period. Manning roughness coefficients of 0.022, 0.026, and 0.045 were used for concrete, bush-wooded, and woodland river banks and 0.03 was utilized for the river base. Flood values of diverse return periods and annual instant maximum flows were obtained from the Turkish General Directorate of State Hydraulic Works. Flood simulations were conducted using hydrodynamic program for the floods of 10, 15, 50, and 100 return periods. It was seen that floods can be prevented in this region by adding levee and regulation of river bottom.

Otherwise, the majority of this flooded area ought to be forested and/or kept as park.

**2.6.4 I. C. OVERTON (2005):** The dams have served to greatly reduce maximum discharges on the river, leading to a decreased spatial extent of inundation. They developed a comprehensive GIS database to support this research. All data were either input or derived within ARC/INFO (a vector-based GIS) or ARC/INFO GRID (a raster-based GIS). ARC/INFO uses the network approach to structure locational information, and the relational approach to structure non-locational information. The eighteen topographic maps (7.5-min quadrangle map series) that cover the study area were developed by the USGS between 1962 and 1977 using photogrammetric methods. Only three of the eighteen DEMs that cover the study area were available for acquisition from the USGS. Sensitivity analyses of the three DEMs indicate that the horizontal and vertical resolutions of the DEMs were below the resolution demands imposed by the study area. Specifically, the topographic subtleties critical to understanding the landforms, moisture variability, and corresponding distributions of vegetation were not well represented in the data or absent altogether from the elevation matrix. Additionally, the three available DEMs were characterized by distinct and regular patterns of striping across the elevation matrix caused by systematic sampling error at the time of DEM construction, and hence were not used in this research. DEMs were derived for all eighteen quadrangles in the study area by digitization of the contour lines and spot elevations from the USGS quadrangles. They scan-digitized the contour lines from Mylar separates of the eighteen 7.5-rain quadrangles. The scanned contours were vectorised during the scanning process and subsequently imported into ARC/INFO GRID and then converted back to the vector data structure. Elevation values were assigned to all of the contours in the coverage's. Finally, point elevation values for benchmarks were manually digitized to additional elevation information for creation of the DEM's. We used the TOPOGR1D module in ARC/INFO to interpolate the digital elevation model from the contour data. TOPOGRID generates a DEM from contour lines, point elevation data, and hydrographic information using an iterative technique of finite difference interpolation developed by Hutchinson (1989). The algorithm interpolates elevation values iteratively using a thin plate spline, thereby developing an optimal flow model that maintains the integrity of the input data while simultaneously ensuring surface continuity (Hutchinson, 1993).

**2.6.5 JOY SANYAL (2003**): Has studied the flood depth from NOAA AVHRR imageries simply by the tonal difference of the flood water. In this study, the flood affected area was subdivided into different flood depth zones using supervised classification. Flood hazard has been assessed by calculating a weighted score for each land use, physiographic and geologic division of the country. The highlight of this methodology is that it assigns greater weight to the categories of deeper flood depth in an exponential manner. Thus by tonal differential method the flood inundation map is produced. Vegetation Index (NDVI) can be used to monitor river inundation from AVHRR images. It is well known that water has a unique spectral signature in the near infrared which is very different from other surface features. Therefore, when a surface feature is inundated its NDVI value changes considerably from the normal situation. Wang *et al.* (2002) observed that in the lower reaches of the Yangtze River, the NDVI value for inundated surface features remains negative while the value for non-inundated surface is commonly greater than 0. But choice of this threshold is critical because natural condition of river flooding varies greatly from place to place. Flood hazard has been assessed by calculating a weighted score for each land use, physiographic and geologic division of the country. The highlight of this methodology is that it assigns greater weight to the categories of deeper flood depth in an exponential manner. Thus by tonal differential method the flood inundation map is produced.

**2.6.6 MATEEUL HAQ, etc. (2012):** The techniques for mapping flood extent and assessing flood damages have been developed which can be served as a guideline for Remote Sensing (RS) and Geographical Information System (GIS) operations to improve the efficiency of flood disaster monitoring and management. The information derived was very essential and valuable for immediate response and rehabilitation. Used Topographic maps had been used to extract different types of info-layers: administrative boundaries, rivers, lakes, roads, railway tracks, vegetated areas and other land use/ land cover categories. Moderate Resolution Imaging Spector-radiometer (MODIS) on board TERRA and AQUA images of 250 m resolution comprising bands 7, 2 and 1 were acquired and used as the principal input to map the flood affected areas. A standard supervised maximum likelihood classification of the images covering Sindh province was carried out and the required inundated class was converted into a shape file. Further editing of the images was carried out by visual interpretation of the inundated areas using expert knowledge. The topographic maps were then intersected with accumulated shape file of the inundated area to extract different types of info-layers for damage assessment. Flow chart of the methodology adopted in this study. The total cumulative flood extent was found to be 21,201 km2 affected 5.88 million people, 5329 settlements, 1500.44 km of road network, 382.05 km of railway tracks, 498.47 km2 of forests and 16440.48 km2 of agricultural land. Flood monitoring using satellite data proved to be an effective method to get quick and precise overview of flooded areas. In the study, timely and detailed analysis had been carried out using RS & GIS for locating and identifying flood affected areas along with land use/land cover features. It was found that this method required processed satellite images which were then overlaid with population density data and land use/land cover maps for damage estimation. The process just required a few hours. The methodology used in this study has the capability to carry out rapid damage assessment.

**2.6.7 KULDEEP CHAURASIA, etc. (2015):** The flood plain delineation mapping has been carried out using Arc Hydro within a Geographical Information System (GIS). Discharges of Yamuna River are recorded by gauging station at the Hathnikund barrage situated in Yamuna nagar district of Haryana state, India at an elevation of 323m. This station is maintained by Irrigation department of Haryana state. Daily average discharges are available since 1995 with the exception of 1998-2001 period. DEM Generation: A high resolution Digital

Elevation Model (DEM) is required to extract the topography information for reliable and accurate flood inundated area mapping. DEM of the study region has been generated from the stereo pair of Cartosat-1 images. The Cartosat satellite carries two high resolution imaging PAN cameras viz. the forward looking camera (Fore) and the afterward looking camera (Aft). Both the cameras capture panchromatic images with a spatial resolution of 2.5 m. The generation of detailed DEM involved five steps: interior orientation, exterior orientation, tie point generation, triangulation and model refinement using Ground Control Points (GCPs). Methodology adopted in this research work mainly consist of 4 steps viz. Image fusion, object based image classification, generation of water surface elevation raster and flood inundated area vector generation. The capabilities of the images can be enhanced if the advantages of both high spatial and spectral resolution can be integrated into one single image that can be done using a process known as image fusion. The outcome of image fusion is a new image which is more worthy for human and machine perception or further image-processing tasks such as segmentation, feature extraction and object recognition. In this paper, PAN (Cartosat-1) imagery has been fused with the MX (LISS-III) using resolution merge approach. Image classification based on spectrum features faces the problem of proper categorisation of the different objects with the same spectral characteristics. This affects the classification accuracy seriously. The imagery has been classified into 9 land use/cover classes. This model takes mainly 4 layers as input to produce the surface water elevation along river. The layers are Time series table containing the water surface elevation along river, Gauge location, vectorised stream and DEM of the study area. The outcomes of the model are surface containing the water elevation in vector and raster formats. Another model takes 3 datasets as input viz. Raster surface with water elevation, vectorised stream and DEM of the study region. The outcome of the Second model is delineated flood plain surface corresponding to the discharged water volume.

## 2.7 BEST MANAGEMENT PRACTISES (BMP'S)

The practices or technics which are more effective and practical in the means of reducing the water pollution and control of flood rate. They may be vegetative, structural or managerial technics. Basically there are five BMP's which are in practice.

- Permeable pavement and permeable pavers
- Bio-Retention
- Infiltration trench and Infiltration well
- Rain Barrel and Cistern
- Vegetated Roof

**2.7.1 PERMEABLE PAVEMENT & PERMEABLE PAVERS**: - The method of paving pavements which enable infiltration of runoff along with transportation for vehicle's and pedestrians. They typically include concrete, coarse aggregate, a little amount of fine aggregate or nil.

Fig.1 Permeable Pavement

**ADVANTAGES:-**

- They are easy to installation
- More durable
- Sustainable
- Low cost
- Can be temporary
- Can be used for lawn parking
- Eliminates costly drainage system
- Used for control of erosion

**DISADVANTAGES:-**

- Expensive to install as compared to traditional pavements.
- Maintenance requirements of this pavement are quite different
- They are not as strong as traditional or asphalt pavement

**2.7.2 BIO-RETENTION:-** This technic consists of shallow depths which are underlain with a gravel layer and planted to capture the specified amount of runoff volume from an impervious layer. In time floods these ponds collects the surface water and filters through the mulch provided.

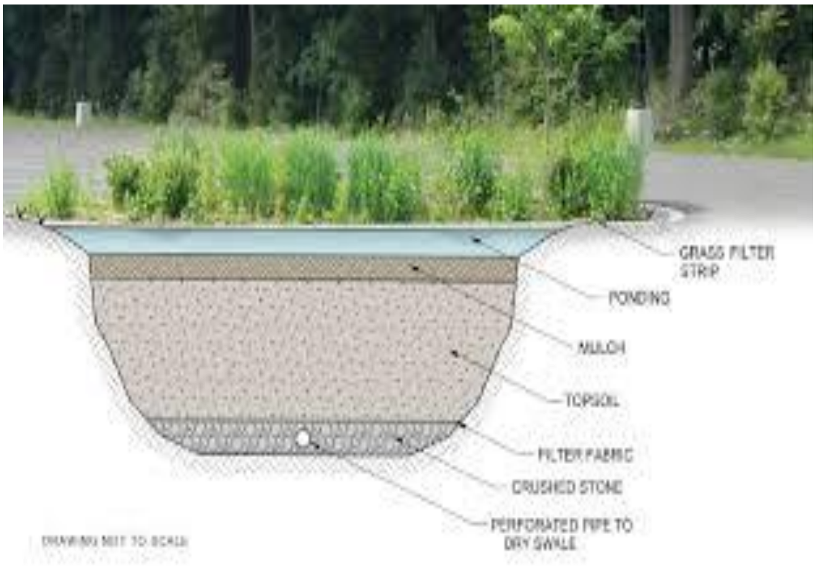



Fig.2 Bio Retention

**ADVANTAGES:-**

- Can be planned based on the topography of the land
- Effective in removing urban pollution
- Reduce the volume and rate of surface runoff
- Flexible layout that fits the landscape
- Effective in high impervious areas
- Better retrofit capability

**DISADVANTAGES:-**

- Requires management team
- Clogging is more is surroundings
- It is not suitable in steep slope areas

**2.7.3 INFILTRATION TRENCHES & INFILTRATION WELL:-** Infiltration techniques are being used to control the surface runoff it may be through wells or trenches. Trench is filled by geotextile filter, fabric and backfilled with stone aggregate after the excavation is done

The well may be bored, drilled, driven etc.; provided with piping facilities to enhance the infiltration capabilities. Based on the structure these wells are also known as “Storage Drainage Well”.


Fig.3 Infiltration Trench

**ADAVANTAGES:-**

- Reduces the volume of runoff from a drainage area
- Can be effective at pollutant removal through filtering
- Capable of ground water recharge

**DISADVANTAGES:-**

- High failure rate due to improper siting, poor design & lack of maintenance
- Comprehensive geotechnical investigations required to confirm suitability
- Not sufficient for draining pollution when there is high concentrations
- Need large area to construct

**2.7.4 RAIN BARREL:-** Rain barrels are nothing but rain water harvesting pits which usually collects the water from building roof tops and store the water in barrel like structure or pit (storage tank). This capacity ranges from 190 to 450 litres in residential areas and 750 to 40,500 litres in industrial areas.

Fig.4 Rain Barrels

**ADVANTAGES:-**

- Most efficient in water conservation
- They are lite and easy to move from place to another
- Easy to install and maintenance

## DISADVANTAGES:-

- Main drawback is the size of the barrel
- To increase the quantity of collection we need to link the multiple barrels
- Leads to the growth of mosquitoes & other insects which leads to cause of diseases

**2.7.5 VEGETATED ROOF: -** Green roofing or Vegetated roof contains a layer of vegetation which is installed on a flat or slope roof. The water drains vertically from the roofs by the soil medium provided and through the waterproof membrane horizontally.

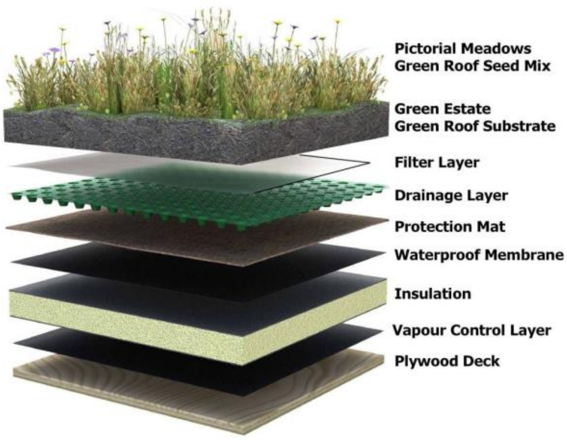



Fig. 5 Vegetated Roof

**ADVANTAGES:-**

- Improve drainage system
- Lifespan of the roof can be increased
- Thermal performance can be increased
- Helps the environment
- It supports the wildlife habitats
- Air quality can be increased

**DISADVANTAGES:-**

- Expensive than traditional roof
- Weight on the roof will be increased
- Extra maintenance is require

# CHAPTER 3

# STUDY AREA

The study area extends over the major place in Andhra Pradesh state named Vijayawada (fig 6). This city is the best example for rapid urbanization. This area is situated along the banks of Krishna River and having an altitude of 11m (36ft) above the sea level. Vijayawada phases the tropical climate with an mean temperature of 23.4 - 34°C (74 – 93°F), maximum temperature often crosses 40°C (104°F), it receives rainfall from South-West and North-East monsoons and the average rainfall recorded was 977.9mm (38.50 in). This city is having approximately 32,000 people for square kilometre. According to their constructions, many of them are built beyond the margin of Krishna River due to over population and availability of less area. Due to this urbanization is constantly increasing and rate of floods is also increasing. The primary issues occurred due to flood are loss of life, damage to buildings and others structures like bridges, drainage systems, transportation. They also effect the power transmission and sometimes power generation i.e. power cut, pollutes the drinking water which leads to harmful diseases. Every year million rupees loss was faced by the government in providing flood relief camps, rebuilding the structures which are effected by the floods etc. All the above mentioned problems are faced by the people who are living these areas every year.

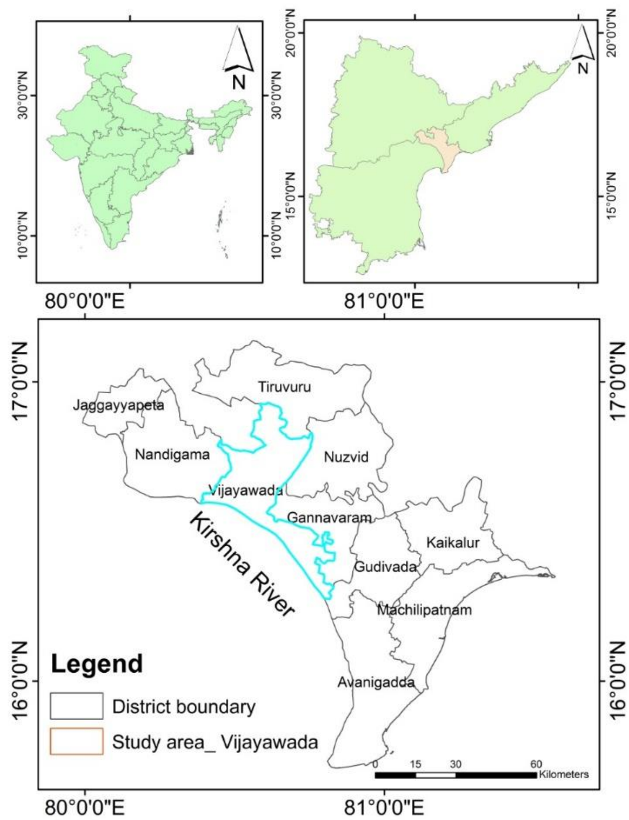
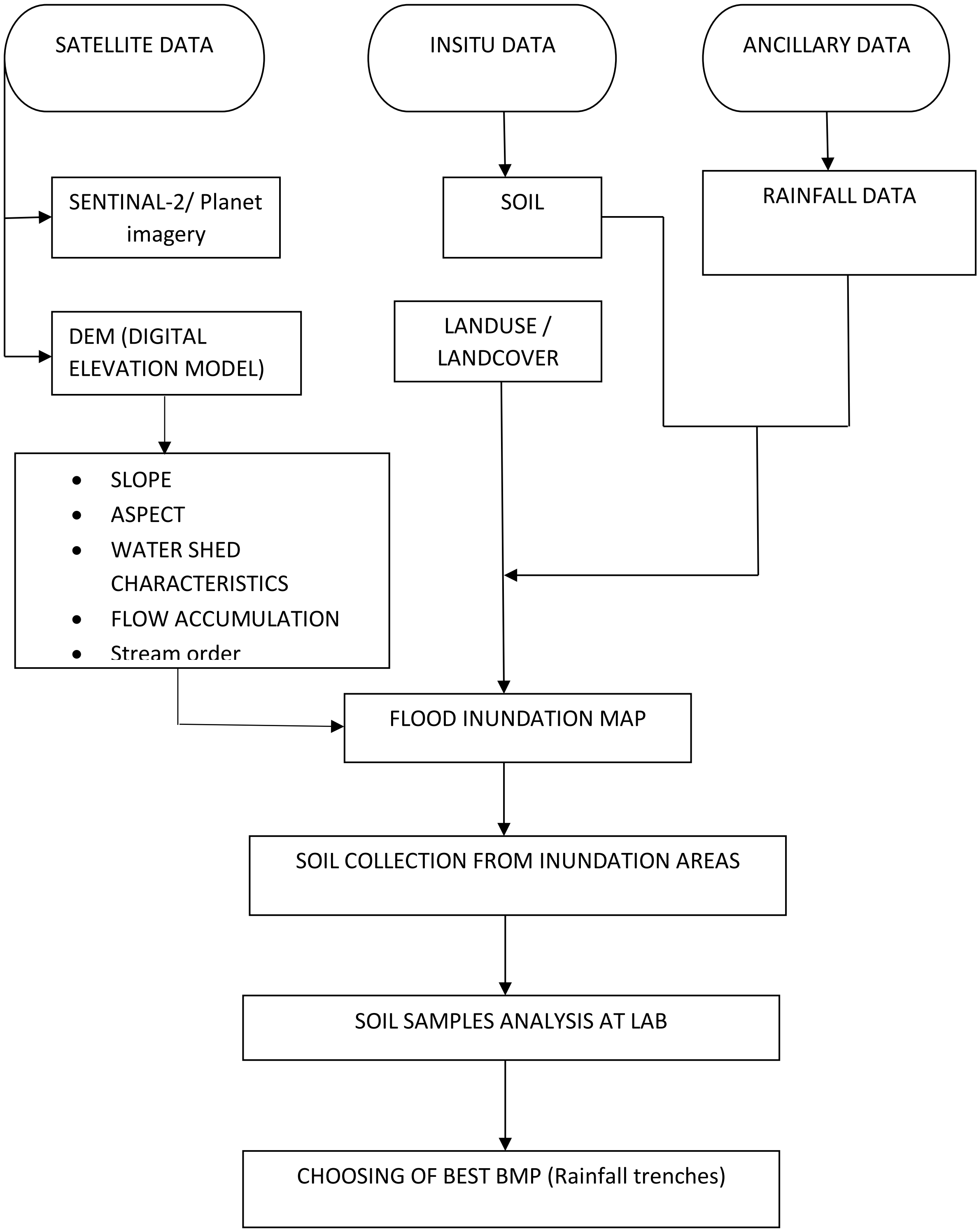



Fig.6 Study Area Map

# CHAPTER 4

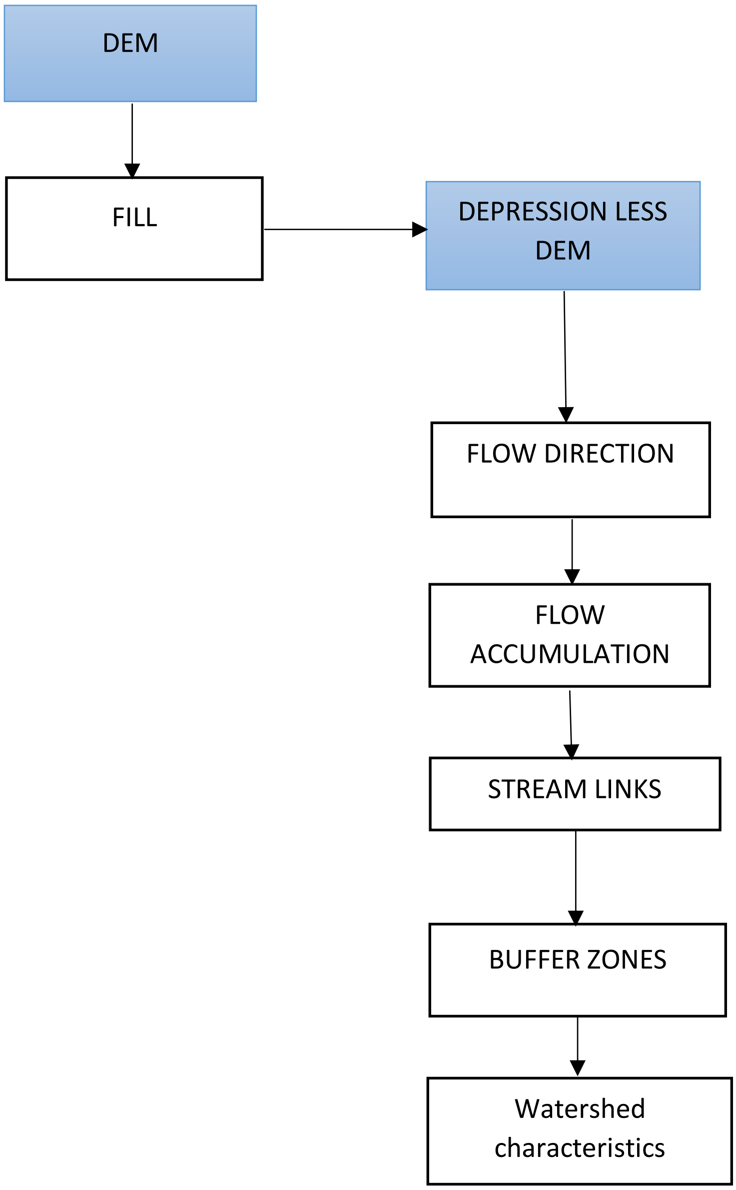
# OVERALL METHODOLOGY



**4.1** GENERATION OF WATERSHED CHARACTERISTICS:

Global Digital elevation model derived from ASTER (write aster characteristics). Is considered in this study for estimation of flood inundation area. For the same, initially Watershed characteristics is generated which acts as a base layer. Further, the intensities of severe, moderate, and low flood inundation zones are identified. Flood zonation is not carried in this study, since it requires many inputs where it couldn't possible to gather because of limitations in data availability

Process of Generation of watershed characteristics: -



## 4.2 GENERATION OF LAND USE / LAND COVER DATA:

Land use is commomnly defined as a series of operations on land, carried out by humans, with the intention to obtain products and/or benefits through land resources.

Land Cover is commonly defined as the vegetation (natural or planted) or man made constructions (buildings, etc.) which occur on the earth surface. Water, ice, bare rock, sand and similar surfaces also count as land cover.

We have considered **unsupervised classification** is where the outcomes (groupings of pixels with common characteristics) are based on the software analysis of an **image** without the user providing sample classes. The computer uses techniques to determine which pixels are related and groups them into classes.

Pixels belonging to a particular cluster are, therefore, spectrally similar. Clustering is a popular technique for image segmentation. Aggregation pheromone brings individuals into closer proximity. This group formation nature of aggregation pheromone is being used as the basic idea of the proposed algorithm. The proposed technique has two parts. In the first part, from the pixels of the input image, clusters of homogeneous pixels (segments) are formed based on property of depositing aggregation pheromone. The number of segments (clusters), thus formed, might be more than the desired number. So, to obtain the desired number of clusters, in the second part, agglomerative average linkage clustering algorithm is applied on these already formed clusters. Clusters so formed represent different homogeneous segments of an image. While performing image segmentation for a given multispectral remotely sensed image, we group similar pixels together to form a set of spectrally similar coherent image regions. Similarity of pixels can be measured based on feature vectors. Different grey level values associated with each band corresponding to a pixel represent the feature vector of a pixel. Clustering is then performed on this set of feature vectors so as to group them. Finally, clustering result is mapped back to the original spatial domain to obtain segmented image (land use map). The proposed unsupervised aggregation pheromone density based clustering (APC) for land use map generation is described below.

Consider a data set of number of patterns and population of where it represents the data pattern. Here each pixel of the input image is assumed as a data point. Like the classification case, the pheromone intensity emitted by modelled by a Gaussian distribution.

The data points which are within a distance are assigned to the newly formed cluster. On the other hand, if the distance between xi and the existing cluster centre is less than 2ı and the ratio of their densities is greater than threshold density (a predefined parameter), then the data point xi is allocated to the cluster having cluster centre. Higher value of density ratio indicates that the two points are of nearly similar density and hence should belong to the same cluster. The proposed unsupervised aggregation pheromone based clustering (APC) algorithm is given in Algorithm 2.

### 4.3 RAIN FALL DATA:

Data is obtained from Indian water portal with a special persmission. Data is obtained on a monthly scale from jnuary to december, 1900 to 2002. This century scale rainfall is further analysed by considering monthly variations of rainfall, so that it will be easy to understand the effect of rainfall in form of floods in different seasons of lowlying areas.

The data is obtained from thewebsite: https://www.indiawaterportal.org/articles/district-wise-monthly-rainfall-data-list-raingauge-stations-india-meteorological-department.

Further, Inverse distance weighted method is used for extrapolating the data at Vijayawada scale (regional scale) to understand the influence of rainfall.

### 4.4 SOIL SAMPLE ANALYSIS

The following techniques are conducted on the soil samples.

**4.4.1 OPTIMUM MOISTURE CONTENT: -** To sight a few, natural moisture content is used in determining the bearing capacity and settlement. The natural moisture content will give an idea of the state of soil in the field.

**APPARATUS:** Used for identifying the moisture content are

- Non-corrodible air tight container
- Electric over, maintain temperature between 105° to 110°
- balance of sufficient sensitivity

**Analyses is carried as follows:-**

1. Cleaned the container with lid, dry it and weigh it (W1).
2. Took the specimen of the sample in the container and weigh with the lid (W2).
3. Kept the container in the oven with the lid removed. Dry the specimen to constant weight maintaining the temperature between 105° to 110° for a period varying with the type of soil but usually 16 to 24 hours.
4. Recorded the final constant weight (W3) of the container with dried soil sample. Peat and other organic soils are to be dried at lower temperature (say 60°) possibly for a longer period.

**FORMULA:**

$$\textbf{Moisture Content} = \{(W2-W_3)/ (W_3-W_1)\} \times 100$$

**4.4.2 SPECIFIC GRAVITY: -**The knowledge of specific gravity is needed in calculation of soil properties like void ratio, Degree saturation etc.

**APPARATUS:-**

- Density bottle of 50ml with stopper having capillary hole
- Balance to weigh the materials (accuracy 10gm)
- Wash bottle with distilled water
- Alcohol and ether

**PROCEDURE:-**

1. Clean and dry the density bottle
    a. wash the bottle with water and allow it to drain
    b. wash it with alcohol and drain it to remove water
    c. wash it with ether, to remove alcohol and drain ether
2. Weigh the empty bottle with stopper ($W_1$)
3. Take about 10 to 20 gm of oven soil sample which is cooled in a desiccator. Transfer it to the bottle. Find the weight of the bottle with stopper and soil ($W_2$)
4. Put 10ml of distilled water in the bottle to allow the soil to soak completely. Leave it for about 2 hours
5. Again fill the bottle completely with distilled water. Now determine the weight of the bottle with stopper and the contents ($W_3$)
6. Now empty the bottle and clean it thoroughly. Fill the bottle with only distilled water and weigh it let it be ($W_4$)
7. Repeat the same process for 2 to 3 times, to take the average reading of it

**FORMULA:-**

$$\textbf{Specific Gravity} = (W_2 - W_1) / \{(W_2 - W_1) - (W_3 - W_4)\}$$

**4.4.3 SIEVE ANALYSIS: -** Sieve analysis is important for analysing materials because particle size distribution can affect the wide range of properties, such as the strength, suitability for various constructions.

**APPARAUS:-**

- Sieves
- Weighing Balance (sensitive to 0.1% of the weight of sample to be weighed)
- Wire brush
- Thermostatically Controlled oven
- Mechanical Sieve Shaker
- Mortar and Rubber Pestle

**PROCEDURE:-**

1. Keep the given representative sample of soil in the oven for 24 hours
2. Pulverize the oven dried sample by using the motar and rubber pestle and sieve it on the 4.75 mm sieve. Take about 500gm of the fraction of the soil passing 4.75mm sieve and retained on 75mm sieve for the sieve analysis
3. Take the following set sieves and stack them one over the other of arrangement shown (i.e. the sieve with the largest

aperture at the top and smallest aperture size at the bottom)

4. Place the sample in the top sieve, Close thelid, transfer the set of sieves with the received pan at the bottom to a mechanical sieve shaker and fir them. Sieve the soil for a period of 10minutes
5. Remove the stack of sieves from the shaker and obtain the weight of the material retained on each sieve
6. Compute the percentage retained on the each sieve by dividing the weight retained on each sieve by the original weight of the soil sample taken for the analysis
7. Compute the percent finer by starting with 100% and subtracting the percentage retained on each sieve as accumulative procedure
8. Draw a graph between the percentage finer, drawn to natural scale on the Y- axis and the particle size drawn to logarithmic scale on the X-axis. Then the plot is called PSD curve.

**4.4.4 FREE SWELL: -**The knowledge of Differential Free Swell gives an idea on the increase of volume of soil without any external constraint when subjected to submergence in water.

**APPARATUS: -**

- Sieve – 425micron IS sieve
- Glass Graduated cylinders – Two

**PROCEDURE: -**

Take two 10gms soil specimens of oven dry soil passing through 425 micron IS Sieve. Each soil specimen shall be poured in each of the two glass graduated cylinders of 100ml capacity. One cylinder shall then be filled with kerosene oil and the other with distilled water up to the 100ml mark. After removal of entrapped air, the soils in the both cylinders shall be allowed to settle. Sufficient time (not less than 24hrs) shall be allowed for the soil sample to attain equilibrium state of volume without any further change in the volume of the soils. The final volume of soil in each of the cylinders be read out.

**CALCULATIONS: -** The level of the soil in the kerosene graduated cylinder shall be read as the original volume of the soil sample, kerosene being a non-polar liquid does not cause swelling of the soil. The level of the soil in the distilled water cylinder shall be read as the free swell level. The free swell index of the soil shall be calculated as follows

$$\textbf{Differential free swell \% } = (V_W - V_K) / V_K$$

Where,

**$V_W$** = the volume of the soil specimen read from the graduate cylinder containing distilled water

**$V_K$ =** the volume of the soil sample read from the graduated cylinder containing kerosene

**NOTE: -**

- If swell of sample less than 50% - non swelling soil
- If the sell between 50 – 100 - medium swelling
- If the swell between 100 – 200 - High swelling
- If the swell of sample more than 200% - very high swelling

# CHAPTER 5

# RESULTS

## 5.1 WATERSHED CHARECTARISTIC MAPS

**5.1.1 DEM ACQUISITION: -** The Digital elevation model is a raster format and can be used in GIS layer for different analyses. In a DEM, each cell of raster GIS layer has a value corresponding to its elevation (values at regularly spaced intervals). DEM data files contain the elevation of the terrain over a specified area usually at a fixed grid interval over the "BARE EARTH".

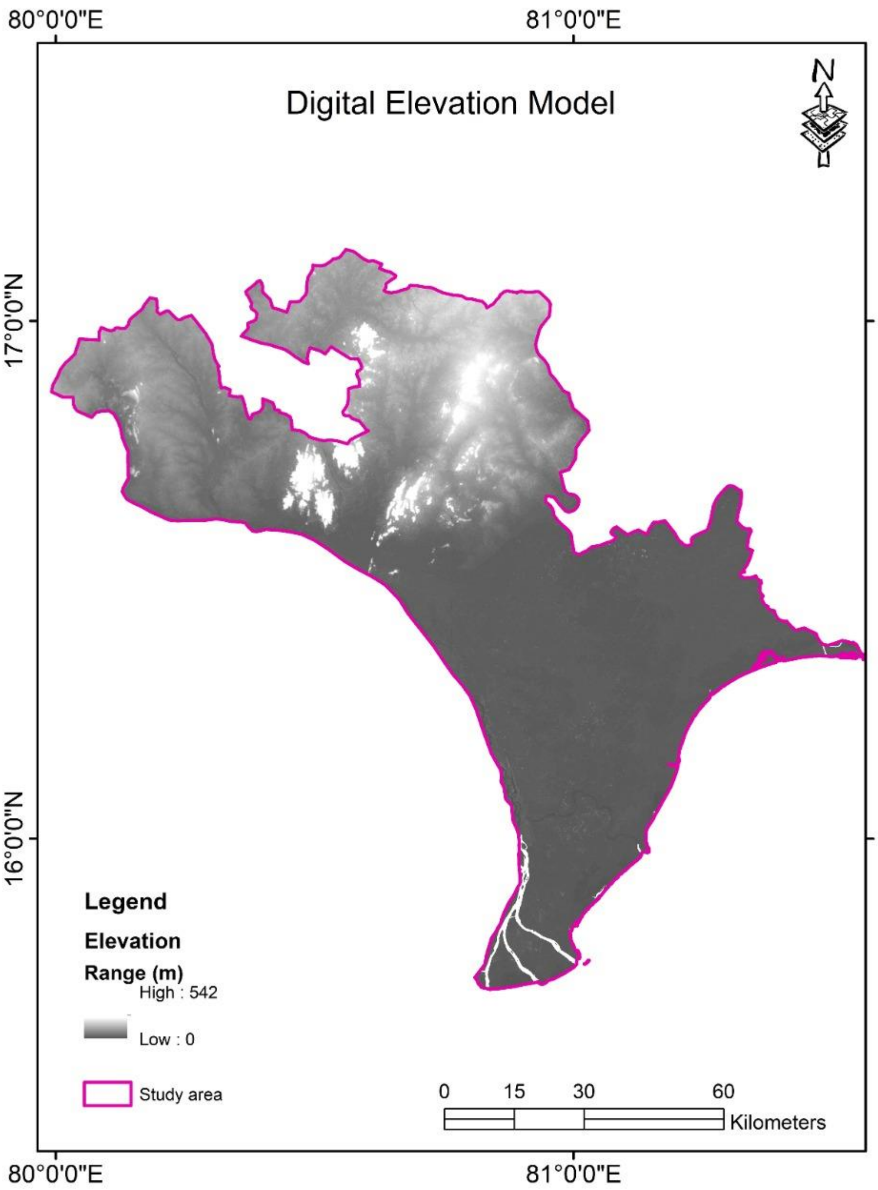



Fig.7 Digital Elevation Model

**5.1.2 FILL: -** Fill sinks in a surface raster to remove small imperfections in the data. A filled DEM or elevation raster is void of depression. A depression is a cell or cells in an elevation raster that are surrounded by higher elevation value and thus represents an area of interval drainage. Although some depressions are real such as acquirers or glaciated pot holes, may be imperfection in the DEM. Therefore, depression must be removed. A common method to remove depression is to increase its cell value to the lowest overflow point out of the sink. This results in the flat surface.

**5.1.3 FLOW DIRECTION: -** A flow direction raster shows the direction water will flow out of each cell of a filled elevation raster. A widely used method for deriving flow direction is the D8 method, used by ARC GIS. In D8 method, assigns a cell flow direction to the one of its eight surrounding cells that has the steepest distance-weighted gradient.

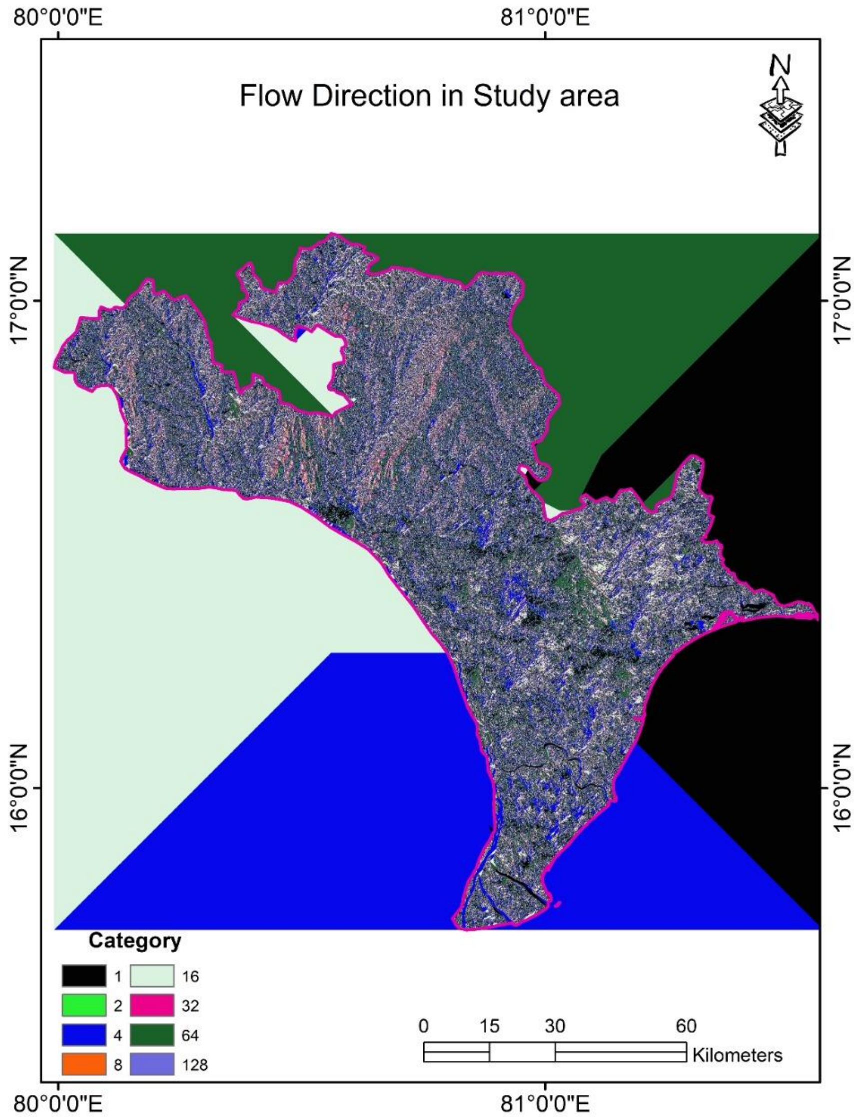



Fig.8 Flow Direction

**5.1.4 FLOW ACCUMULATION: -** A flow accumulation raster tabulates for each cell the number of cells that will flow to it. The tabulation is based on the flow direction raster.

A flow accumulation raster can be interpreted in 2 ways:-

1. Cells having accumulation values generally correspond to stream channels, whereas cells having an accumulation value of zero generally corresponds to rigid lines.
2. If multiplied by cell size, the accumulation value equals to drainage area.

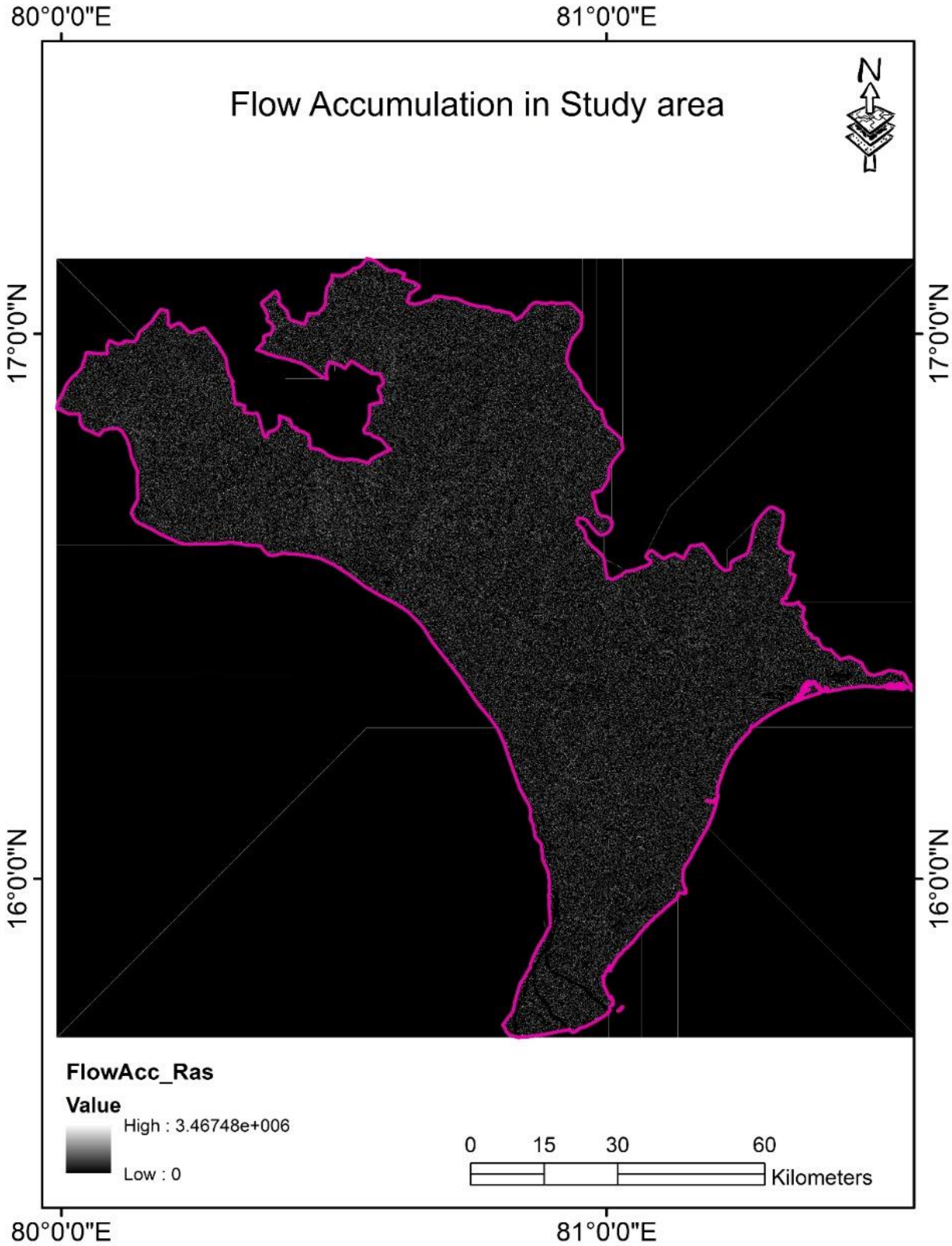



Fig.9 Flow Accumulation

**5.1.5 STREAM LINKS: -** Assigning a unique value and associating with flow direction to each section of stream network is a steeper producer to derive stream links. A stream link raster therefore resembles a topology based stream layer, the intersections or junctions are like arcs or reaches.

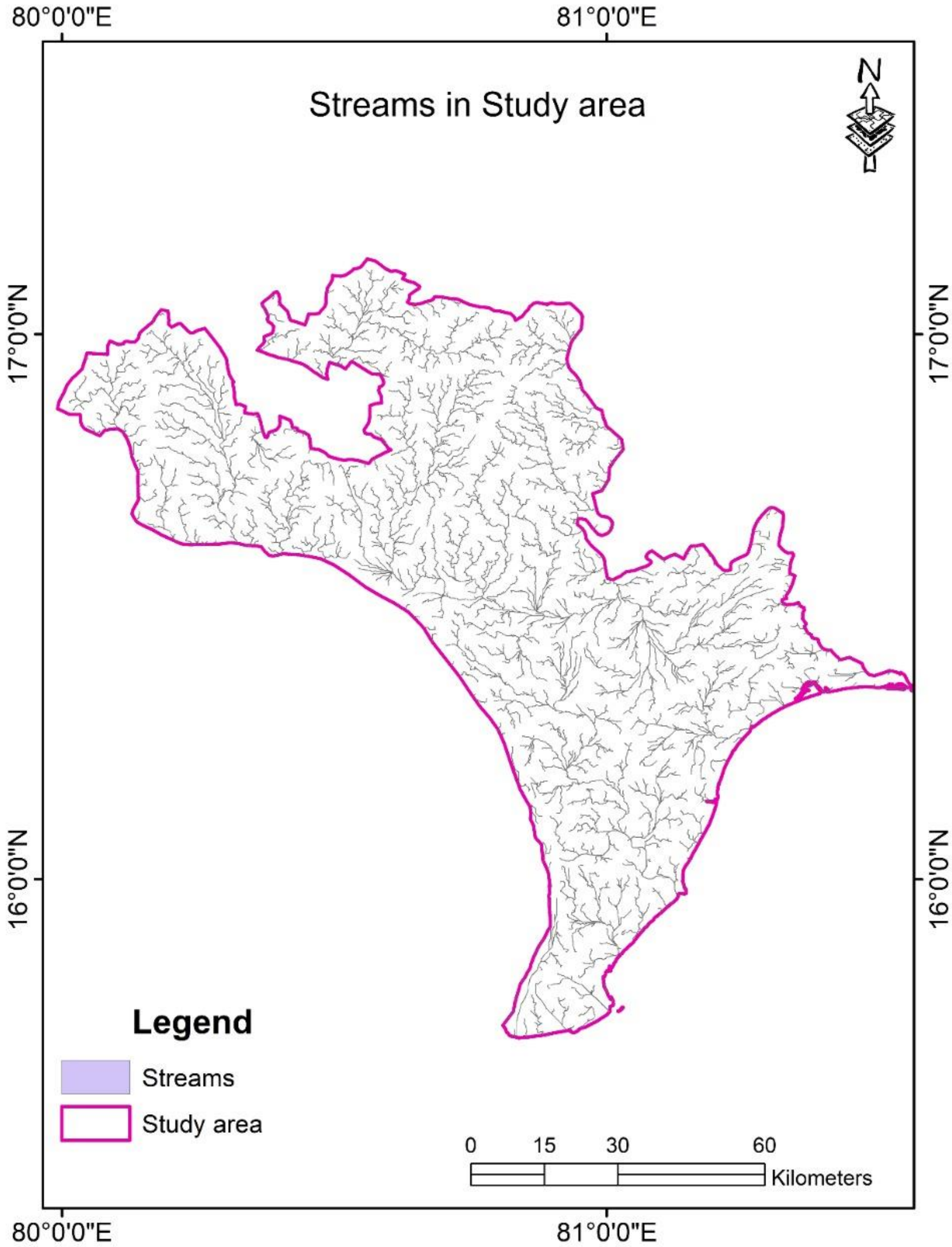



Fig.10 Stream Links

**5.1.6 BUFFER ZONES: -** A buffer zone in GIS is a zone around a map feature measured in units of distance or time. A buffer is useful for proximity analysis. A buffer is an area defined by the bounding region determined by a set of points at a specified maximum distance from all nodes along segments of an object.

Weightages are given as below: -

- > 1500m is 3 rank
- 1000 – 1500m is 4
- 500 – 1000m is 5 (higher rank)

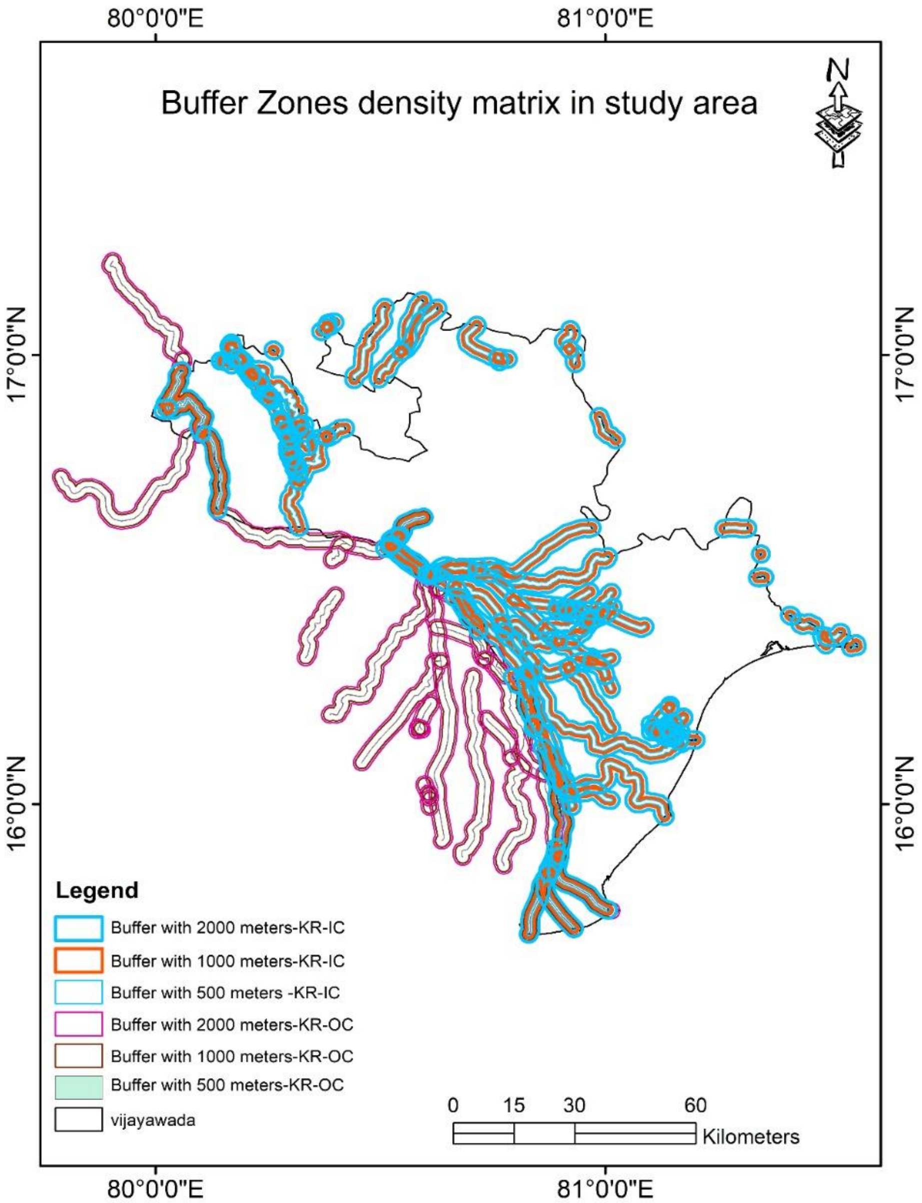



Fig.11 Buffer Zones

**5.2 LAND USE / LAND COVER DATA: -**

Unsupervized classification is used to extract the values by alloting weightages to the Raw data. Generally it is between 1 to 5.

- River - 4
- Sand Areas – 3
- Vegetation / Roads – 2
- Other Areas - 1

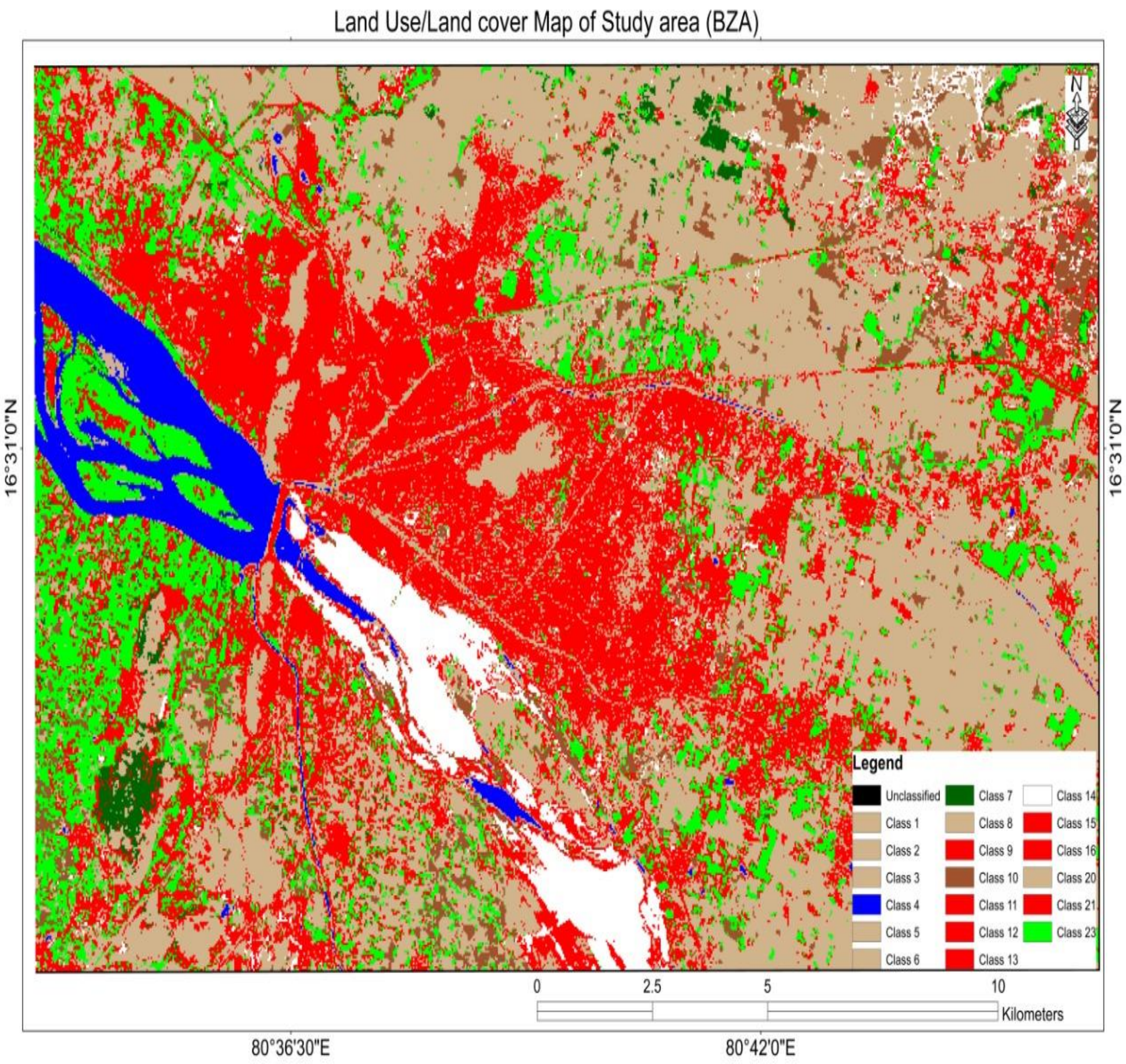



Fig.12 Land Use / Land Cover Data

## **5.3** RAIN FALL DATA: -

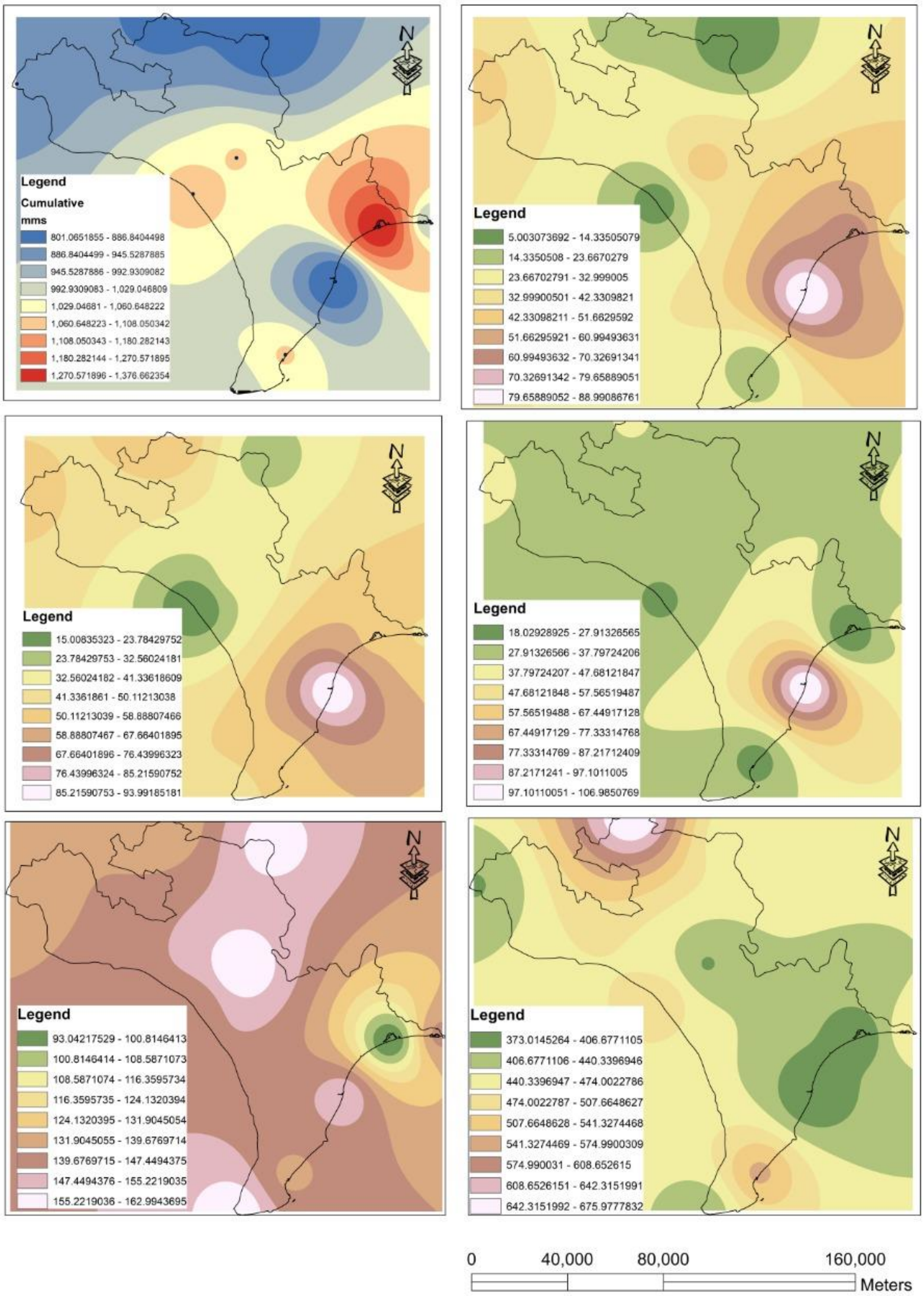



Fig.13 Rain Fall Data Map (1)

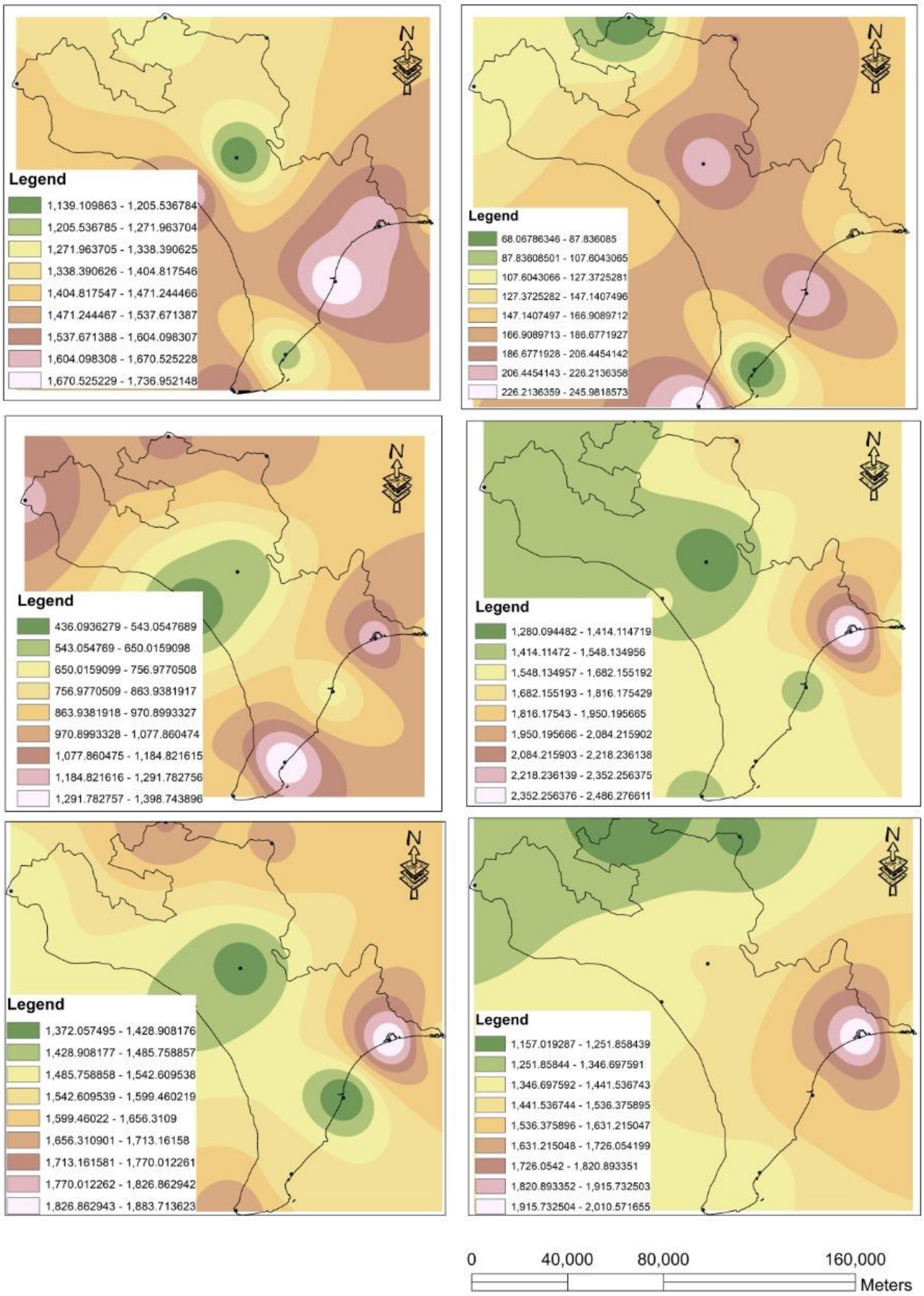



Fig.14 Rain Fall Data Map (2)

## 5.4 INUNDATION MAP: - The identified inundation zones are: -

- Krishna Lanka
- Yanamalakuduru are the two major low lying areas observed to be flooded with minimum rain. Hence, further study is carry only in these two areas

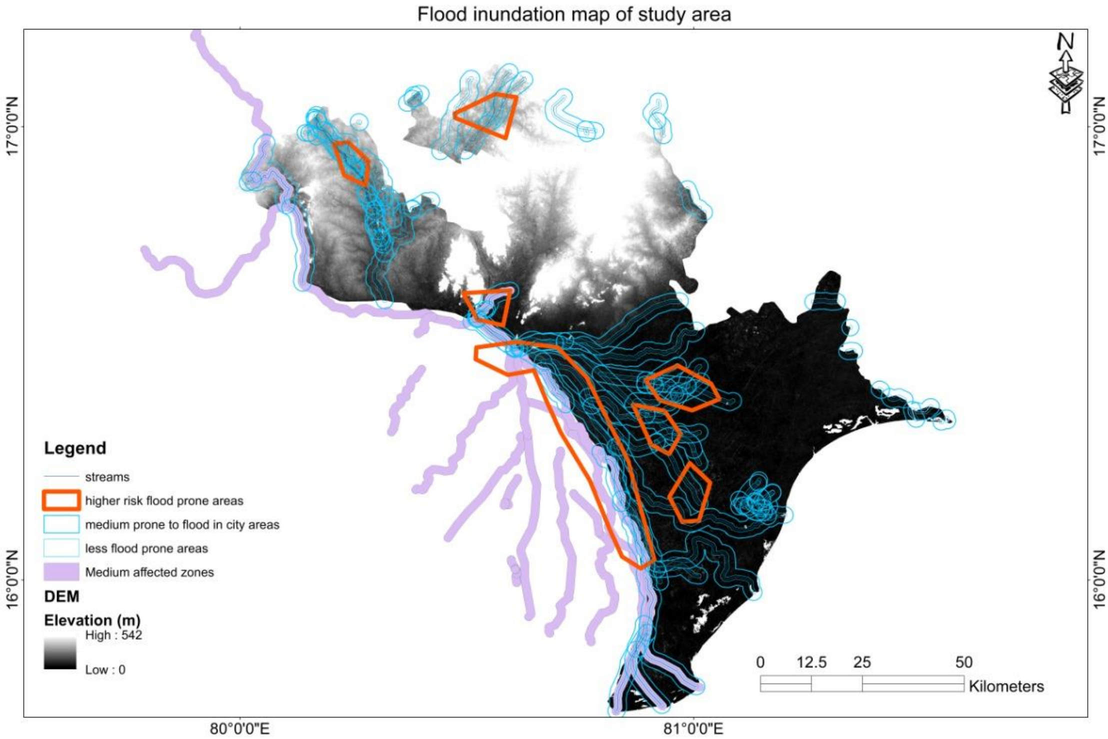



Fig.15 Inundation Map

## 5.5 SOIL COLLECTION FROM THE IDENTIFIED INUNDATION ZONES

- Soil is collected from the inundation zones.
- Soil sample is collected from the depth of 1.5m below the ground level.

Fig.16 Soil Collection

## 5.5.1 MOISTURE CONTENT TABULAR FORMS AND VALUES

| S.NO | OBSERVATIONS | TRAIL 1 | TRAIL 2 |
|---|---|---|---|
| 1 | Wt. of container with lid (w1) gm. | 34 | 34 |
| 2 | Wt. of container + wet soil (w2)gm. | 50 | 50 |
| 3 | Wt. of container with + dry soil (w3)gm. | 48 | 49 |
| 4 | Moisture content | 14.28% | 6.66% |

1. Moisture content table of Krishna Lanka soil

| S.NO | OBSERVATIONS | TRAIL 1 | TRAIL 2 |
|---|---|---|---|
| 1 | Wt. of container with lid (w1)gm. | 34 | 34 |
| 2 | Wt. of container + wet soil (w2)gm. | 50 | 50 |
| 3 | Wt. of container with + dry soil (w3)gm. | 48.5 | 49 |
| 4 | Moisture content | 10.344% | 6.66% |

2. Moisture content of Yanamalakuduru

**RESULT:-**

1. The optimum moisture content of Krishna lanka soil = 18.6%
2. The optimum moisture content of Yanamalakuduru soil = 14.83%

## 5.5.2 SPECIFIC GRAVITY TABULAR FORMS AND VALUES

| S.NO | OBSERVATIONS | TRAIL 1 | TRAIL 2 |
|---|---|---|---|
| 1 | Weight of density bottle ($W_1$) gm. | 28 | 28 |
| 2 | Weight of density bottle+ dry soil (W2) gm. | 48 | 48 |
| 3 | Weight of bottle + dry soil + water (W3) gm. | 88 | 87 |
| 4 | Weight of bottle + water (W4)gm. | 80 | 80 |
| 5 | Specific Gravity | 1.66 | 1.53 |

3. Specific Gravity of Krishna Lanka soil

| S.NO | OBSERVATIONS | TRAIL 1 | TRAIL 2 |
|---|---|---|---|
| 1 | Weight of density bottle ($W_1$) gm. | 28 | 28 |
| 2 | Weight of density bottle+ dry soil (W2) gm. | 48 | 48 |
| 3 | Weight of bottle + dry soil + water (W3) gm. | 90 | 88 |
| 4 | Weight of bottle + water (W4)gm. | 80 | 80 |
| 5 | Specific Gravity | 2 | 1.66 |

4. Specific Gravity of Yanamalakuduru soil

**RESULT:-**

1. The specific gravity of Krishna lanka soil = 1.595
2. The specific gravity of Yanamalakuduru soil =1.833

## 5.5.3SIEVE ANALYSIS

PARTICLE SIZE DISTRIBUTION TABLE

| GRAVEL | SAND | | | SILT | CLAY |
|---|---|---|---|---|---|
| | Coarse | Medium | Fine | | |
| Grain size | 4.75 | 2.00- | 0.425- | 0.075- | < |
| range in mm >4.75 | 2.00 | 0.425 | 0.075 | 0.002 | 0.002 |

**COMMENTS:-**

- From the grain size distribution (GSD) curve grain sizes such as $D_{10}$, $D_{30}$, and $D_{60}$ may be obtained. D refers to the grain size while the subscript (10, 30, and 60) denotes the percentage finer.
- Thus $D_{10}$ = 0.10mm indicates the diameter of the particle corresponding to 10 percent finer or in the other words, 10% of the sample has grains smaller than 0.10mm
- From the above values, two quantities, namely the co-efficient of uniformity ($C_u$), and the co-efficient of curvature ($C_c$), may be computed using the following formulae.

$$\mathbf{C_u = D_{60} / D_{10}}$$

$$\mathbf{C_C = (D30)^2 / (D_{60} \times D_{10})}$$

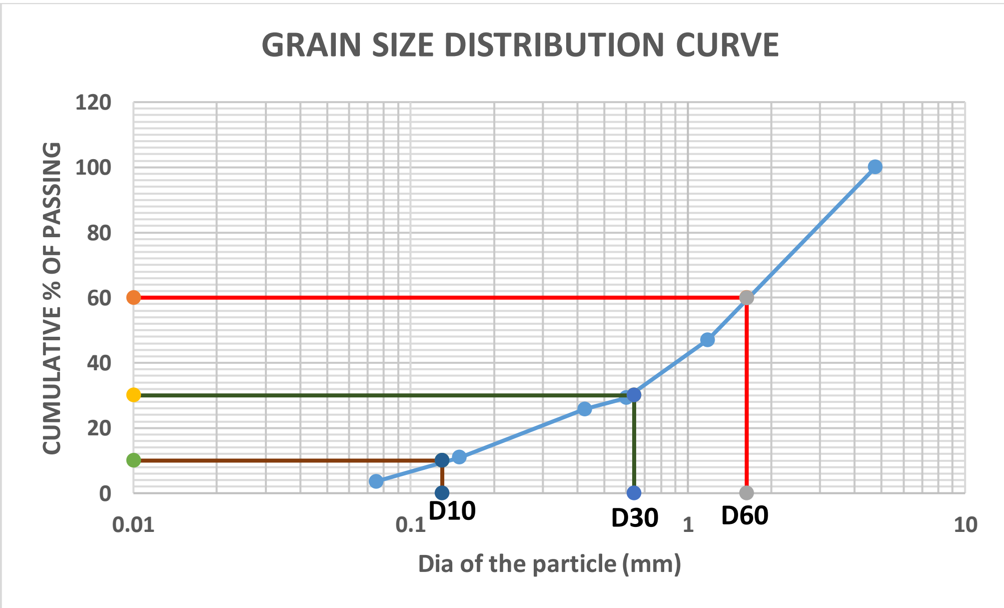
- These quantities enable one to know whether the soils are well graded (W) i.e., it has a good representation of all particle sizes, or poorly graded/ gap graded/ skip graded (P) i.e., a good representation of all particle sizes does not exit.
- For a well Graded soil/ Uniformly Graded soil,

**$C_u$**>**4** for **GRAVELS**
**$C_u$**> **6** for **Sands** and
**$C_c$** must be between **1** and **3** for **both**
If the above criteria are not met, the soil may be termed as poorly graded (P).
For a uniform soil: - **$C_u$**< **1**

| S.NO | IS sieve size | Particle size (D) mm | Weight retained (gm.) | % weight retained | Cumulative % weight retained | Cumulative %finer (% Passing) |
|---|---|---|---|---|---|---|
| 1 | 4.75 | 4.75 | 0.098 | 9.8% | 0% | 100% |
| 2 | 1.18 | 1.18 | 0.432 | 43.2% | 53% | 47% |
| 3 | 600 | 600 | 0.178 | 17.8% | 70.8% | 29.2% |
| 4 | 425 | 425 | 0.034 | 3.4% | 74.2% | 25.8% |
| 5 | 150 | 150 | 0.148 | 14.8% | 89% | 11% |
| 6 | 75 | 75 | 0.74 | 7.4% | 96.4% | 3.6% |
| 7 | Pan | Pan | 0.36 | 3.6% | 100% | 0% |

**OBSERVATIONS: -**

5. Grain Size Distribution For Krishna Lanka Soil




Graph 1

$D_{10}$ = 0.13mm

$D_{30}$ =0.625mm

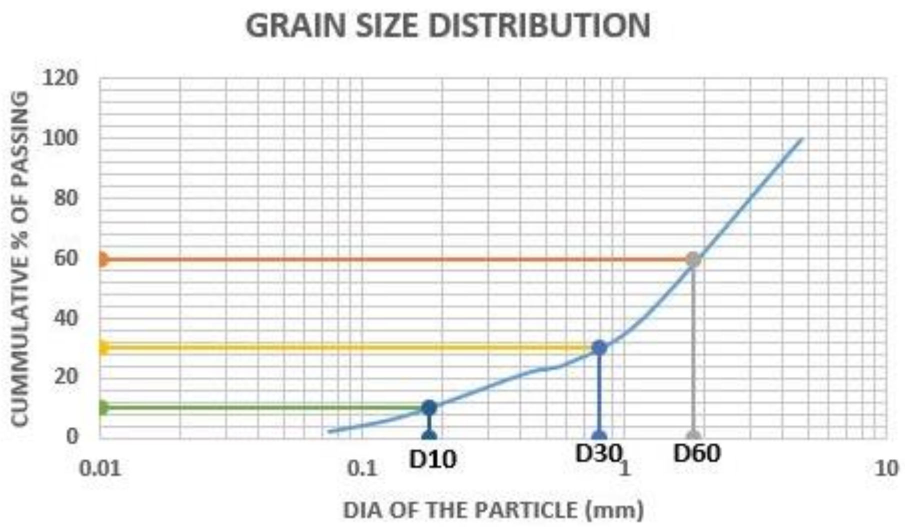
$D_{60}$ =1.63mm

$C_U = D_{60} / D_{10} = 1.63 / 0.13 = 12.53$

$C_C = (D_{30})^2 / (D_{60} \times D_{10}) = (0.625)^2 / (1.63 \times 0.13) = 1.84$

| S.NO | IS sieve size | Particle size (D) mm | Weight retained (gm.) | % weight retained | Cumulative % weight retained | Cumulative %finer (% Passing) |
|---|---|---|---|---|---|---|
| 1 | 4.75 | 4.75 | 0.234 | 23.4% | 0% | 100% |
| 2 | 1.18 | 1.18 | 0.366 | 36.6% | 60% | 40% |
| 3 | 600 | 600 | 0.152 | 15.2% | 75.2% | 24.8% |
| 4 | 425 | 425 | 0.034 | 3.4% | 78.6% | 21.4% |
| 5 | 150 | 150 | 0.136 | 13.6% | 92.2% | 7.8% |
| 6 | 75 | 75 | 0.056 | 5.6% | 97.8% | 2.2% |
| 7 | Pan | Pan | 0.022 | 2.2% | 100% | 0% |

6. Grain size distribution tabular form for Yanamalakuduru soil




Graph 2

$D_{10}$ = 0.179mm

$D_{30}$ =0.8 mm

$D_{60}$ =1.82 mm

$C_U = D_{60} / D_{10} = 1.82 / 0.179 = 10.16$

$C_C = (D_{30})^2 / (D_{60} \times D_{10}) = (0.8)^2 / (1.82 \times 0.179) = 1.96$

**RESULT: -** According the CC and CU values obtained from the calculation

1. Krishna Lanka soil sample is uniformly graded sand
2. Yanamalakuduru soil sample is uniformly graded sand

5.5.4 DIFFERENTIAL FREE SWELL OBSERVATIONS AND VALUES

OBSERVATIONS: -

Differential free swell % = $(V_W - V_K) / (V_K)$
$= ((13 - 10) / (10)) \times 100 = 30\%$

Differential free swell % = $(V_W - V_K) / (V_K)$
$= ((14.5 - 10) / (10)) \times 100 = 45\%$

**RESULT: -**

- The KrishnaLanka soil sample is Non-Swelling soil
- The Yanamalakuduru soil is Non-Swelling soil

Fig.17 Differential Free Swell

Fig.18 Sieve Analysis

Fig.19 Specific Gravity

Fig.20 Weighing

Fig.21 Moisture Content

## **5.6 CHOOSING BEST BMP**:

By considering the 5 available BMP's, we are choosing RAIN BARRELS because the soil type is clay which takes long time to penetrate the water itself by which we can't reduce the flood rate. Bio Retention type BMP is used in the fields and to construct the Infiltration Trenches, the place is not sufficiently available. Vegetated roofs are in practice in day to day life but not enough efficient to control the flood. Finally based on the based on the Soil condition, Density of Population, Land use / Land Cover Data, Type of Rain Fall, Climate, Amount of Rain Fall, Availability of land RAIN BARRELS is choosed as the best suitable BMP for that area.

# CHAPTER 6
# SCOPE OF FUTURE STUDY

Designing of RAIN BARRELS based on the quantity of flood in that area is the further process of this study. By providing the required dimensioned barrels we can control the flood rate and at the same time we can reduce the damages which occur to the life style of the people.

# CHAPTER 7
# CONCLUSION

By installing the required dimensioned RAIN BARRELS in the identified inundation zone i.e. Krishna Lanka and Yanamalakuduru, we can reduce the flood rate and at the same time we can reuse the water for bathing, laundry, flushing toilets, watering the lawns, gardens and houseplants, composting, water for pets, outdoor ponds, and rinsing vegetables by storing it. We can recharge the ground water table by not letting it as a waste product in to the sea.

# CHAPTER 8

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