EVALUATION OF SPATIAL AND TEMPORAL CHANGES IN GROUNDWATER LEVELS USING RS AND GIS – A CASE STUDY OF MALLEBOINPALLI AREA, MAHABOOB NAGAR DISTRICT, A.P.(STATE).

A Thesis
Submitted For Partial Fulfillment
Of The Requirement For The Degree
of
MASTER OF TECHNOLOGY
in
ENVIRONMENTAL MANAGEMENT

By
V. RAMA LAKSHMI
(Roll No.01031D3136)

Under the guidance of

P. Venkateswarlu,
Assistent Professor,
Center for Environment,
J.N.T.University,
Masab Tank,
Hyderabad.

Dr. S.P Wani,
Principle Scientist (Watersheds).and,
Regional Theme Coordinator,
ICRISAT, Patancheru,
Hyderabad.

CENTER FOR ENVIRONMENT
INSTITUTE OF POST GRADUATE STUDIES AND RESEARCH
JAWAHRLAL NEHRU TECHNOLOGICAL UNIVERSITY
HYDRABAD
2003

International Crops Research Institute for the Semi-Arid Tropics

ICRISAT

Patancheru 502 324
Andhra Pradesh
India

Tel +91 40 3296161
Fax +91 40 3241239
+91 40 3296182
Email icrisat@cgiar.org

25 September 2003

TO WHOMSOEVER IT MAY CONCERN

This is to certify that the project work entitled "Evaluation of Spatial and Temporal Changes in Groundwater levels using RS and GIS - A case study of Malleboinpalli Area, Mahaboobnagar District, A.P. State" is a bonafied work of Ms. V. Rama Lakshmi, Regd No: 01031D3136, which was duly completed by her under my guidance as a part of her MASTER OF TECHNOLOGY in Environmental management to the Jawaharlal Nehru Technological University and her work and efforts are appreciated.

Suhas P Wani
Principal Scientist (Watersheds) and
Regional Theme Coordinator

CERTIFICATE

This is to certify that the thesis entitled **"EVALUATION OF SPATIAL AND TEMPORAL CHANGES IN GROUNDWATER LEVELS USING RS AND GIS – A CASE STUDY OF MALLEBOINPALLI AREA, MAHABOOB NAGAR DISTRICT, A.P"**, that is being submitted by V. RAMA LAKSHMI in partial fulfillment for the award of the degree of MASTER OF TECHNOLOGY IN ENVIRONMENTAL MANAGEMENT to the Jawaharlal Nehru Technological University is a record of bonafide work carried out by him under my guidance and supervision.

The results embodied in this thesis have not been submitted to any other University or Institution for the award of any degree or diploma.

Internal Guide

P. Venkateswarlu
Assistant professor,
Center for Environment,
J.N.T.University,
Hyderabad.

Principal Guide

Dr. S.P. Wani,
Principal Scientist(Watersheds) and
Regional Theme Coordinator,
ICRISAT,
Hyderabad.

ACKNOWLEDGEMENTS

I am very much grateful to my guide **Dr. S.P. Wani**, Principle Scientist, ICRISAT, Hyderabad for his valuable guidance and co-operation from time to time in carrying out this thesis work.

I am highly thankful to Prof. **K. Anjaneyulu**, Head, Center for Environment and Associate Professor **K. Anji Reddy** , **P. Venkateswarlu**, GIS , Center for Environment for their support and suggestions during this thesis.

My sincere thanks to **Dr. R.S. Dwivedi**, Scientist and **Dr.K.V. Ramana**, Soil and Agriculture, NRSA for his constant help for visual image interpretation.

This project work is a part of Andhra Pradesh Rural Livelihood Programs(APRLP), supported by DFID-UK. I grateful acknowledge the help of **Ms. T.K. Sreedevi**, Addl. Govt. of A.P., project coordinator and **Mr. Takker**, Project coordinator, APRLP for their support for the work and sharing data for this work.

I am thankful to **Md. Irshad Ahmed**, Scientific officer and **Md. Moinuddin**, Associate(GIS), ICRISAT for their co-operation through out the thesis.

I am thankful to **Mr. B. Satyanarayana**, Geologist (Sr), and **Mr.M.Raju**, Geologist (Sr), Geographical Survey of India, Hyderabad for collecting geology map of our study area and also give the valuable ideas for preparing the groundwater prospect map.

I am thankful to all other staff members of Center for Environment and my classmates for making my studies memorable and pleasant.

I am indebted forever to my parents for their love and encouragement throughout my academic career.

At last, but not least, that my sincere appreciation to my beloved husband with whose co-operation, affection and encouragement, I could complete my thesis happily.

- V.RAMA LAKSHMI

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ABSTRACT

The present study was carried out to delineate and characterize groundwater prospect zones during the year 2002 and 1998 using PAN and LISS – III merged data, MSS geocoded data on 1: 50,000 scale. The information on geology, geomorphology, land use/ land cover, slope were generated and integrated to prepare groundwater prospect map for the area of Malleboinpalli in Mahaboob Nagar District. The information on type of well, depth range, yield range, pumping time, well position were supplemented to form a good database for identification of favorable zone. Geographical Information System was used to prepare database on the above layers and composite map. On the basis of geomorphology, six categories of groundwater prospect zones : excellent, good, moderate, normal to poor, poor, very poor are delineated. The high prospect zones valley fills yield in 2002 >15.8 bgl (m). The pediplain with moderate weathering, Pediplain with shallow weathering, pediplain, residual hills, inselburgs indicate good, moderate, normal to poor, poor, very poor groundwater prospect zones. In the study area groundwater levels are decreasing compared to the during years 1998 and 2002. Recommended the some groundwater recharge structures and also suggest the suitable site for digging of wells.

CHAPTER –1

INTRODUCTION

1.1. Watershed management:

General –

A watershed is defined as any surface area from which runoff resulting from rainfall is collected and drained through a common point. It is synonymous with a drainage basin or catchment area. A watershed may be only a few hectares as in small ponds or hundreds of square kilometers as in rivers. All watersheds can be divided in to smaller sub-watersheds. As each watershed or sub-watershed is an independent hydrological unit, any modification of the land used in the watershed or sub-watershed will reflect on the water as well as sediment yield of the watershed.

The watershed or catchment is the natural framework for resource development in relation to crop production system and resource conservation and utilization.

A watershed is made up of the natural resources in a basin, especially water , soil, and vegetative factors. Watershed management is the integration of technologies within the natural boundaries of a drainage area for optimum development of land, water, and plant resources to meet the basic needs of people and animals in a sustainable manner. This included land improvements, rehabilitation, and other technical works as well as betterment of people.

Improved watershed management offers many potential benefits for the local community, and the larger cross section of society. Proper management of soil and water is essential to meet the basic needs of human beings for food, fiber, and fuel, and for livestock. Rainfall is the main source of water for crop production in rain-fed agriculture. It must be efficiently managed and used for stabilizing crop production as well as maintaining ecological balance in watersheds.

Watershed management in watersheds includes

- collection of water in crop lands to increase infiltration.
- Collection and harvesting of excess rainfall.

- Efficient storage of harvested water.
- Water application (lifting and conveyance).
- Optimal utilization of applied water for maximum benefit.

For increasing crop productivity and sustainability of agriculture in a region, conjunctive use of rainfall and groundwater in a watershed is essential. Over exploitation of groundwater will adversely affect long-term sustainability of agriculture in the region. Crops that give more benefit per unit of irrigation should be grown. Cropping system should be restricted to growing seasonal crops with low water requirements. Crops which require perennial irrigation and large amounts of water such as rice and sugarcane should not be cultivated (Singh and Pathak, 2003).

Proper management of soil and water is essential to meet the basic needs of human beings for food, fiber, and fuel, and for fodder for livestock. Rainfall is the main source of water for crop production in rain-fed agriculture. It must be efficiently managed and used for stabilizing crop production as well as for maintaining ecological balance in watersheds. Low rainfall areas, dry spells within the rainy season may cause fluctuations in crop production. Flooding due to heavy downpour may result in water loss with concomitant losses of soil and nutrients.

Therefore, it is practical to develop integrated water conservation and management practices to mitigate drought and to moderate floods. Rainwater can be managed both at fields scale (farmer's level) and at watershed scale (community level) to derive maximum benefit.

Integrated watershed Management is an approach to manage the natural resources for increasing productivity on sustainable basis in the watersheds through a holistic approach (Wani et al., 2001). The main objectives of Integrated watershed management are :

- To increase the productivity and income from the dry-lands through introduction of improved technologies with respect to different components of watershed program.
- To improve the collection of runoff through appropriate water harvesting system and enhance productivity through increased water use efficiency.
- To conserve the soil resource for achieving the sustained productivity.

- To generate the employment potential at the village level.
- To enhance the productivity of community lands through social forestry, pasture development for minimizing land degradation.

1.2. Reason for Selection of Area:

Malleboinpalli area is economically backward area. This area mainly depends on agriculture. Groundwater and rainwater are main source for irrigation. In this area rainfall is decreasing for the last five years and groundwater potential is also decreasing in this area. In view of the drought prone, rain-fed agriculture, vageries of the monsoon, even depleting groundwater levels and the plight of the rural poor are the reasons for the selection of the study area.

1.3. Groundwater in General:

Groundwater is precious and most widely distributed natural resource of earth. The world's total water resources are estimated at 1.37×10^8 m.ha.m (Ragunath,1987). Of these about 97.2 % is salt water, in oceans and only 2.8 % is available as fresh water at any time on the earth. Out of this 2.8 % about 2.2 % is available as surface water and 0.6 % is available as groundwater. Out of this 2.2 % surface water 2.15 % is fresh water in the form of glaciers and icecaps. About 0.01 % is available in lakes and reservoirs and 0.0001 % in streams, the remaining being in other forms.

Of the groundwater component of 0.6 % only 0.3 % is extractable economically (Ragunath,1987). The average annual groundwater recharge from rainfall and seepage from canals and other irrigation system is of the order of 67 m.ha.m. of which only 4 % that is 27 m.ha.m is extractable economically. The present utilization of groundwater is 13 m.ha.m.

The recurrent failures of monsoon and the depletion of groundwater table created severe drought conditions in many parts of the country. In unconsolidated formations, the occurrence and movement of groundwater is mostly confined to the zones of material with primary porosity. In consolidated and semi consolidated formations it is largely controlled by weathering fracturing, jointing, faulting, cracks etc. Since groundwater is a sub surface phenomenon there is a need to understand the surface hydrological conditions, through the surface expressions.

Aerial photographs are in use for hydro geological mapping for several years, subsequent to the advent of space-based Remote Sensing, however, the satellite data are being widely employed for deriving groundwater exploration parameters especially through visual interpretation techniques. In general satellite image interpretation in conjunction with aerial photographs and conventional methods of surveying helps in satellite areas of promising occurrence of groundwater.

Maps of groundwater potential zones prepared from satellite images, serves as efficient tools for narrowing down potential zones for detailed ground- based hydro geological surveys which ultimately lead to the selection of suitable sites for Bore wells/ Dug wells. Satellite data offers the unique capability for extracting information on geology, drainage, land use/ land cover and soil from a single image. Information on all these factors is essential in understanding the occurrence and movement of groundwater.

The integrated surveys has the advantage of narrowing down the areas for further exploration. Consideration of the different thematic information in totality helps to generate a more complete and reliable frame work for formulation of groundwater exploration program.

In olden days the pollution was not a problem as it is not present or if present is in minute quantities, the ecosystem had capability for combating the pollution, in its own structured, organized ways. The pollutants before the industrialization were mostly biodegradable or they can be easily converted into biodegradable forms by physical, chemical and, biological ways. The resulting products were not harmful to the local ecosystems and were in molecular to atomic forms. But the present industrialization and urbanization has resulted in the pollution of air, land and, water.

Water is one of the vital natural resources for sustenance of life. To meet the ever – increasing demand for water for domestic and agricultural activities, it is necessary to have a time and cost effective technology for groundwater resource assessment and management. Geographical Information System technique, in conjunction with remote sensing, has the potential to provide time and cost effective, up-to-date information about natural resources in general and groundwater resources in Malleboinpalli area and suggest optimal and conjunctive use of water resources as assessed by remote sensing and GIS.

1.4. Importance of Remote Sensing technology:

Watershed management requires exhaustive data and information, which are very dynamic in nature, and temporally changes overtime and space due to natural and external influence on agro-climatic environments. Using conventional methods, it becomes highly difficult to collect the data from remote and wide spread areas. Moreover, the collected data are often inadequate, outdated and time consuming besides being more expensive. Under these circumstances, Remote Sensing technology has immense contribution in providing synoptic and unbiased information on large areas at periodical intervals.

1.5. Description of the Study Area :-

Location:

The Malleboinpalli area located in Mahaboob Nagar District of Andhra Pradesh and situated between-

Longitude : $78^0$04'48" $78^0$08'24" E

Latitude : $16^0$43'48" $16^0$46'48" N

This area occupy 35.05 Km^2.

Elevation of GL wrt MSL (m) 543.310. Total depth bgl(ml) 31.05.

Physiography:

The physiography of the study area is nearly flat with gentle sloping. The Peddavagu is the main stream having branch of Krishna.

Geology:

The area mainly consists of Granites in different forms.

Soils types

Soil type	Depth in cm	Fertility	Moisture retention depth in cm	Moisture retention period
Red clay loam soils	45-60	Good	30	15-20 days
Red sandy soils	60-105	Medium	90	10 days
Saline and alkaline soils	90	Poor	90	30 days
Light black soils	90-120	Good	90	30 days

Table : 1 (Source – ICRISAT Micro watershed's Baseline data)

Rainfall:

Year	Avg. rainy days	Avg. Rainfall in mm
1998	4	65.7
1999	3.33	48.9
2000	3.5	59.1
2001	3.9	59.4
2002	3.6	39.9

Table : 2 (Source: Department of Statistics and Economics, Hyderabad)

The area is in drought prone area of Mahaboob Nagar District. Intermittent droughts in the cropping seasons is a regular feature. There are no check dams in the area. Moderate levels of soil erosion.

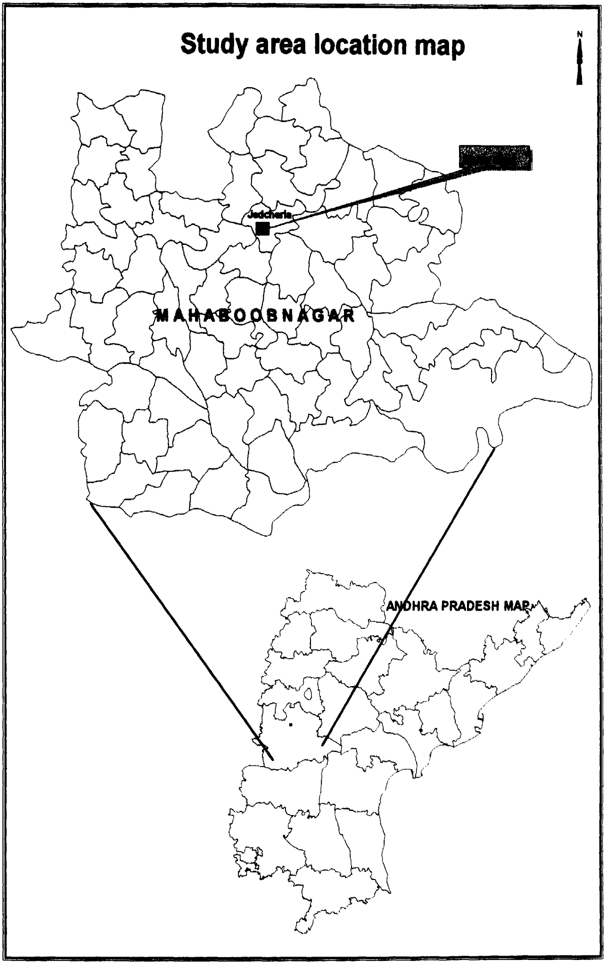

Study area location map
N
Jadcherla
MAHABOOBNAGAR
ANDHRA PRADESH MAP

Fig 1. PAN image of the study area (13-02-2003)

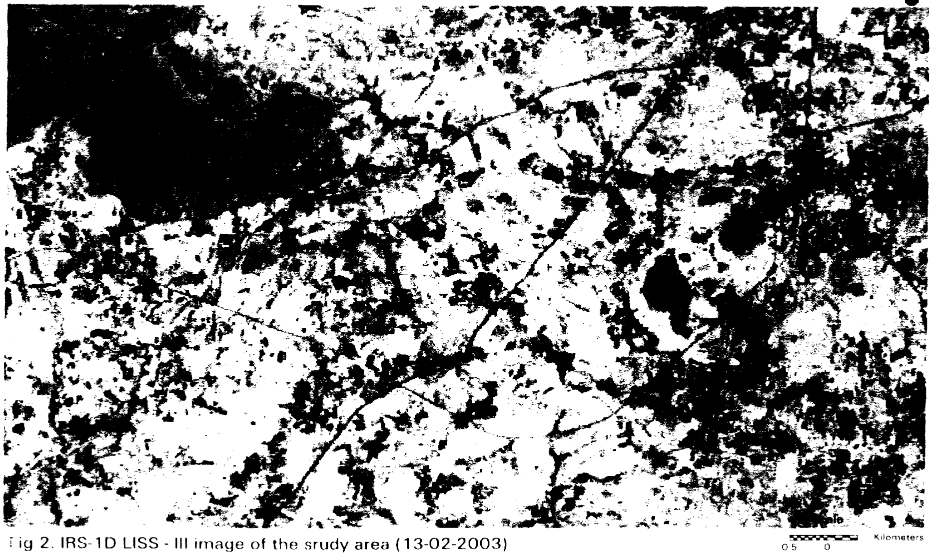


Fig 2. IRS-1D LISS - III image of the srudy area (13-02-2003)

Fig 3. LISS-III and PAN merged image of part of the study area

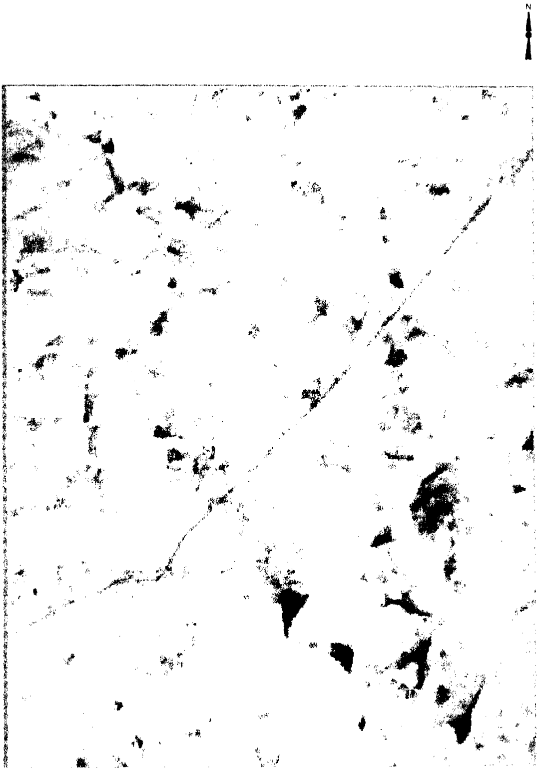


Fig : 4 Landsat MSS image of the study area(1998)

1.6. Objectives:

1. To delineate different geo-morphological units in study area using PAN and LISS III merged image.
2. To create Land Use/ Land Cover Map and Lineament Map, Slope Map.
3. To prepare the Groundwater prospect maps of 1998 and 2002.
4. To assess the groundwater potential status based on integration of groundwater level data and geomorphology making the impact assessment of watershed area during the years (1998 and 2002).

CHAPTER – 2

REMOTE SENSING
&
GEOGRAPHICAL INFORMATION SYSTEM IN WATER RESOURCES

2.1. Introduction:

Watershed management requires exhaustive data and information, which are very dynamic in nature, and temporally changes overtime and space due to natural and external influence on agro-climatic environments. Using conventional methods, it becomes highly difficult to collect the data from remote and widespread areas. Moreover the collected data are often inadequate, outdated and time consuming besides being more expensive. Under these circumstances, Remote Sensing technology has immense contribution in providing synoptic and unbiased information on large areas at periodical intervals.

2.1.1. Remote Sensing:

Remote sensing is the technique of gathering information about objects and features without being in physical contact with them. Information is acquired by detecting and measuring changes that the object imposes on the field, be it an electromagnetic, acoustic, or potential field. The human eye with its muscular controls and retina is perhaps the best examples of Remote Sensing System. For example, it is commonly known that an analyst can discriminate only about 8 to 16 shades of gray when interpreting continuous tone black and white image/photo . If the data are originally recorded with 256 shades of gray, there may be more suitable information present in the image that the interpreter can extract visually. In such cases digital image processing techniques are found to be more effective. In many respects, Remote Sensing can be through of as a reading process. Using various sensors we remotely collect data that may be analyzed to obtain information about the objects, areas, or phenomena being investigated. And there are two types of sensors, i.e Active and Passive certain sensors, such as RADAR Systems, supply their own source of energy to illuminate features of interest. These are called as "Active Sensors".

In contrast the 'Passive Sensors', that sense naturally available energy. A very common example of an active sensor is a camera used with flash. The same when system used in sunlight becomes a passive sensor.

Electromagnetic energy sensors are currently being operated from airborne and space-born platforms to assist in inventorying, mapping and monitoring earth resources. These sensors acquire data on the way various earth surface features emit and reflect electromagnetic energy and these data are analyzed to provide in-formation about the resources under investigation.

Remote Sensing of earth resources involves two basic process steps, namely data acquisition and data analysis.

A Remote Sensing System using electromagnetic radiation has four components

- A source.
- Interactions with earth's surface.
- Interactions with earth's atmosphere.
- A sensor.

Source:

The source of electromagnetic radiation may be natural like the Sun's reflected light or the Earth's emitted heat on man-made like microwave radar.

Earth's surface interactions:

The amount of characteristics of radiation emitted or reflected the earth's surface is dependent upon the characteristics of the objects on the earth's surface.

Atmospheric interaction:

Electromagnetic energy passing through atmosphere is distorted and scattered.

Sensors:

The electromagnetic radiation that has interacted with the surface of the earth and the atmosphere is recorded by a sensor 2.3.1.

2.1.2. The Electromagnetic Spectrum:

Electromagnetic radiation occurs as a continuum of wave length and frequencies from short wave length, high frequencies cosmic waves to long wave lengths that are great interest in Remote Sensing are visible and near infrared radiation in the waveband 0.4-3.0 micrometers. Infrared radiation in the waveband 3.0-14micrometers and microwave radiation in the waveband 5.0-500micrometers. The electromagnetic energy is divided in to a number of spectral regions.

2.1.3. Platforms for Remote Sensing:

Platforms are one from which a sensor can operate. Platforms can vary from stepladders to space stations. Historically the first aerial photographs were taken 1858 from a balloon, which floated over Paris. Up until 1946, Remote Sensing data were mainly acquired from airplanes or balloons. In 1946, pictures were taken from V-2 rockets. The sounding rocket photography provided invaluable potential value of photography from orbit altitudes. With advent of space systems a new dimensions has been added to Remote Sensing.

Bhaskara satellites fabricated in India are junior members of this category. Systematic orbital observations of the earth began in 1960 with the launch of TIROS – 1, there first meteorological satellite in 1961. Orbital color photography was acquired by an automatic camera in the unmanned MERCURY spacecraft. This is followed by photography acquired during the MERCURY, APOLLO, and SKYLAB missions. On APOLIO – 9 first multi-spectral images were acquired to access their use for Earth observation.

In 1972, first earth resource technology satellites [ERTS – I later renamed as LANDSAT-1] was launched, which was one of the major milestones in the field of Earth Remote Sensing. ERIS – I was followed by a series of LANDSAT missions. Earth orbital spacecraft are also used to acquire Remote Sensing data other than regular photography. To name just a few, the NIMBUS, the Synchronous Meteorological Satellite (SMS), SKYLAB (1972), and SEASAT (1978) etc... In 1981, the space shuttle provided a new platform for Remote Sensors, The second shuttle flight carried a package of earth oriented sensors including an imaging RADAR, a multi-spectral radiometer, and a visible ocean scanner.

2.1.4. Indian Remote Sensing Program:

Remote Sensing is an important part of the Indian space program and the Department of Space (DOS). Government of India, is the nodal agency for the realization of the National Natural Resource Management System (NNRMS), the National Resource Information System (NRIS) and the Integrated Mission for Sustainable Development (IMSD), besides several other national level application projects in close collaboration with the user agencies. As part of this program, it has acquired the capability to design, develop and operate state-of-the-art multi sensor satellite based-systems comprising of space, ground and application segments to meet domestic and international requirements.

2.1.5. Indian Remote Sensing Satellite Missions:

The following satellite missions are the important milestones, which have been achieved, in the realization of indigenous end-to-end capabilities.

Bhaskara – 1 and 2 :-

These were experimental remote sensing satellites launched in June 1979 and November 1981 respectively. Their payload consisted of TV cameras, radiometers.

IRS- 1A / 1B :-

These were operational first generation remote sensing satellites with two Linear Imaging Self-scanning Sensors (LISS – I and LISS – II) for providing data in four spectral bands (invisible and near infra-red regions) with a resolution of 72.5m with a repetitivety of 22 days. These satellites were launched in March 1988 and August 1991 respectively. Even though the design life was three years, IRS – 1A was in service till October 1992 and IRS – 1B is still in service, providing good quality data.

IRS – P2: -

The satellite was launched in October 1994 on the indigenously developed polar satellite launched vehicle (PSLV – D2), IRS – D2 carries a modified LISS camera.

IRS – 1C: -

This was the first of the second generation, operational, multi sensor satellite mission with improved sensor and coverage characteristics, besides having an On Board Tape Recorder (OBTR) for obtaining data outside the visibility of ground stations. The IRS – 1C was launched successfully on December 26,1995 and the data is being received, processed and disseminated from ground stations in India, U.S.A, Germany, Taiwan and Thailand. The three sensors On – Board IRS – 1C satellite are – PAS sensor with a resolution of 5.8m (at nadir) single band in the visible region, with a swath of 70km (at nadir) and $\pm 26^0$ across track till capacity.

LISS –III multi- spectral sensor with a resolution of 23.5m in three visible near Infra-red and 70.5m short wave Infra- red (SWIR) band and a swath of 141km.

Wide field sensor (WiFS) with a resolution of 188m, two bands in the visible /near Infra - red region and swath of 810km.

IRS- P3: -

This satellite was launched in April 1996, on PSLV – D3 and has two imaging sensors and one non-imaging sensor viz. Wide Field Sensor (WiFS) with a resolution of 188m and swath of 810km, similar to IRS-1C WiFS, but having an additional SWIR band, Modular Optical Electronic Scanners (MOS) mainly for oceanography applications and an X – Ray astronomy payload, WiFs and MOS data products are being disseminated to users.

IRS – 1D: -

IRS – 1D is the first of the second generation operation, Indian Remote Sensing Satellite missions with better resolution, coverage and revisit. IRS-1D was launched by indigenously developed Polar Satellite Launch Vehicle (PSLV) from Sriharikota, India on 29th September 1997. The satellite is placed in a near circular, Sun-Synchronous, near polar orbit with a nominal inclination of 98.53^0, at a mean altitude of 780km.

2.1.6. Remote sensing Application mission:

With the successful completion of IRS-UP projects, some of the major applications have been identified in the themes of agriculture, soils and land use, water resources, ocean/marine resources, forestry and geology to be taken up in 'mission mode'. The salient aspects of the Remote Sensing Application Mission projects are-

Agricultural crops, soils, land use, and drought:

- Large area crop acreage estimation of a few selected crops (wheat, rice , ground nut, cotton and sorghum) and integration with yield relationships for making trial production estimates.
- Development and demonstration of remote sensing based yield models for wheat and rice.
- Mapping saline/alkaline soils of India for a selected state.
- Inventory and mapping of land use/ land cover using high resolution data for the whole country.
- Inventory and monitoring urban sprawl of all the major cities.
- Identification, classification and monitoring of drought at all India level.

Land and water resources:

- Identification of erosion prone areas in selected major watersheds.
- Preparation of flooded area maps for major river basins.
- Preparation of groundwater potential maps for drought prone areas of India.

Ocean Resources and Environment:

- Mapping and monitoring of the coastal environment.
- Evaluation of the littoral process around major harbors.

2. 2. Geographic Information Systems (GIS)

2.2.1. Introduction :

Over the past two decades it has become increasingly apparent that resources are becoming more scare, the effect of human activities more pervasive and the recognition and the prediction of causes and effects more complex. It has also been recognized that better resource assessment and planning methods yield direct benefits in improved resource management and ultimately in improved quality of life. Geo-referenced information has always been critical to the welfare of the country, it is the technology and methods such as computer - based information systems and remote sensing that can provide the means to inventory resource and model process from the local to global scale. The need for a computer-based information system that efficient handling analysis of geo-referenced data has evolved Geographical Information System (GIS). GIS is collection of computer hardware, software, experienced personnel for input management data storage and retrieval, manipulation and output of geo - graphically referenced data and the corresponding attributes. A GIS is generally designed for the collection, storage and analysis of objects and phenomenon where geographical location is an important characteristic to the analysis. In other words a GIS may be defined as computer-based information system which attempts capture, stores, manipulate, analyse, and display spatially referenced and associated tabular attribute data, for solving research, planning, management problems. Such as system will normally embody.

- A database of spatially referenced data consisting of location and associated tabular database.
- Appropriate software components encompassing procedures for interrelated transactions from input via storage and retrieval, and the adhering manipulation and spatial analysis facilities to output (including specialized algorithms for special analysis and specialized computer languages for special queries) and associated hardware components including high- resolution graphics display, large capacity electronic storage devices which are organized and interfaces in an efficient and effective manner to allow rapid data storage , retrieval and management capabilities and facilitate the analysis.

2.2.2. Components of GIS:

A GIS may be considered as a subsystem of an information system which it self has five major component subsystems including:

- Data input processing
- Data storage, retrieval, and database management
- Data manipulation and analysis.
- Display and product generation.
- A user interface.

These main components are summarized in data input covers all aspects of transforming spatial and non-spatial (textural or feature attribute) information from both printing and digital files into a GIS database. To capture spatially referenced data effectively, a geographical information system should be able to provide alternative methods of data entry. These usually include digitizing (both manual and automatic), satellite images, and scanning and keyboard entry. The data may come from many sources such as existing analogue maps, aerial photographs, and remote sensing surveys and other information systems. Often the data require operations of manual or automated processing prior to encoding, including format conversion, data reduction and generation of data, error detection and editing, merging of points into lines, edge matching, rectification and registration, interpolation etc... The level of measurement of these data may vary and range from categorical to ratio data, and from fuzzy and stochastic information to precisely measured data.

Database management functions control the creation of and access to the database it self. For the storage, integration and manipulation of large volumes of different data types at a variety of spatial scales and levels of resolution, a GIS hat to provide the facilities available with in a Database Management System (DBMS). Most commercial GIS (such as, for example: ARC/INFO) have a dual architecture. The non – spatial attribute information is stored in a relational database management and the spatial information in a separate subsystem, which enables to deal with spatial data spatial queries. Such architecture, however reduces, the performance because objectives have to be retrieved and compiled from components stored in the two subsystems. This problem is not easy to solve. Spatial data processing is performed with vector, raster or a combination of the geometric data formats.

The Most important and distinguishing feature, which a GIS has over a mere computer mapping systems or CAD, is the ability to manipulate and analyze spatial data. The manipulation and analysis procedures, which are usually integrated in a GIS, are often limited, however, to simple spatial operations such as:

- Geometric calculation operators such as distance, length, perimeter, area, closest intersection and union.
- Topological operators such as neighborhood, next link in a polyline network, left and right polygons, start and end nodes of a polyline.
- Spatial comparison operators such as intersects inside, larger than, outside neighbor of etc.//
- Multi layer spatial overlay involving the integration of nodal, linear and polygon layers, and to restricted forms of network analysis.

Product generation is the phase where final products from geographical information system are created. The display and products may take various forms such as statistical reports, maps and graphics of various kinds, depending upon the characteristics of the media chosen. These include video screens for an animated time sequence of displays similar to a movie, laser printers, inkjet and electrostatic plotters, color film readers, micro-film devices and photographic media.

The final module of a geographical information system consists of software capabilities, which simplify and organize the interaction between the user and the GIS software via, for example menu driven common systems.

It is note–worthy that most current GIS are strong in the sophisticated forms of spatial analysis and decision making make them best suitable for natural resource management. As mentioned earlier, the analytical possibilities basically and usually refer to polygon overlay with analysis. GIS capabilities for location – allocation problems, optimal land use allocation and management routing vehicles for delivery of goods and services.

2.2.3. Classification of GIS Analysis Functions:

The development of GIS techniques has provided a constantly growing number of ever more sophisticated analysis functions. A description of even the most common functions would quickly overwhelm the unlimited. The following shows the classification of analysis functions.

- Maintenance and Analysis of the spatial data transformations – Format, Geometric transformations, transformation between map projections, conflation, edge matching, editing of graphic elements, line coordinate thinning.

- Maintenance and Analysis of the attribute data – Attribute editing functions, attribute query functions.

- Integrated Analysis of Spatial and Attribute data – Retrieval, classification, measurement, overlay operations, search, line in polygon and point polygon, topographic functions, Thesien polygon, interpolation, neighborhood operations, contour generation, connective functions, contiguity measures, proximity, network, spread, seek, intervisibility, illumination, perspective view.
- Output Formatting – Map annotation, text labels, texture patterns.

Graphic Symbols: -

The first level of classification contains four groups mainly maintenance and analysis of the spatial data. Maintenance and analysis of the attribute data, Integrated analysis of spatial and non – spatial data and output formatting. Each major group is sub divided into types of function. The distinction among these categories is some what artificial and not clear, but they do provide a useful frame work.

The way that GIS function is implemented depends on such factors as the data modal (e.g.: Raster Vs Vector), The hardware and performance criteria (e.g. How fast it must run. what

The way that GIS function is implemented depends on such factors as the data modal (e.g.: Raster Vs Vector), The hardware and performance criteria (e.g.: How fast it must run, what options must be provided). These details are important and require considerable expertise to properly evaluate. However, This level of details is not needed to understand the types of analysis functions that a GIS can provide, how they are used and why they are valuable.

2.2.4. Application of GIS:

Some of the GIS applications include agricultural and land use planning, forestry and wild life management, archeology, geology, municipal applications, civil engineering, Remote Sensing, urban and regional planning, business and commercial applications. The easy acceptability and implementation of GIS are making it very popular for various applications. The three dimensional analysis is having applications in terrain evaluation, highway route allocation, canal planning etc.

2.2.5. Implementing GIS:

The implementation of GIS can be seen as a six-phase process.

A). Awareness: People with in the organization become aware of GIS technology and the potential benefits their organization. Potential uses and users of GIS are postulated.

B). Development of systems requirement: The idea that GIS could benefit the organization is formally acknowledged and a more systematic and formal process is instituted to collect information about technology and to identify the potential users and their needs. A formal need analysis if often done at this stage.

C). System Evaluation: Alternative systems are proposed and evaluated. The evaluation process takes into account the need analysis of the previous phase. At the end of this phase a formal decision must be made where or not to proceed with acquisition of GIS.

D). Development of an implementation plan: having made the decision to proceed with acquisition of a system, a plan is developed to acquire the necessary equipment and staff, make organizational changes and find the process. This plan may be a formally accepted document or a more or less informal series of actions.

E). System organization and start – up: The system is purchased, installed, staff is trained, creation of database is begin and operating procedures begin to be established. Creation of the database is usually the most expensive part of the implementation process. Considerable attention is needed to establish appropriate data quality. Controls to ensure that the data entered meet the required standards and those suitable updating procedures are implemented to maintain the concurrency and integrity of the database.

F). Operational phase: By this stage the initial automation of the database is complete and operating procedures have been developed to maintain the database and provide the information services that the organization requires. In this phase procedures are developed to maintain the GIS facility and upgrade services so that the GIS continues to support the changing information needs the organization. Operational issues concerning the responsibilities of the GIS facility to provide needed services and to guarantee performance standards become more prominent

CHAPTER – 3

REVIEW OF LITERATURE

3.1. Groundwater prospecting in watersheds:

Watershed is a land area from which rainwater drains to a common point and is a hydrologic unit of surface expression. Watershed constitutes the natural spatial frame for harnessing and utilizing the water resources, surface and subsoil and improving the moisture retentivety of land. Planning of watershed development depends on their scientific delineation and codification. For proper assessment of potential, present use and additional exploitability at optimal level, of both surface as well as groundwater resources, it is widely acknowledged that a basin wise or catchment wise approach yields the best results.

Evaluation, development and management of groundwater resources are often handicapped by non – availability of historic water – level data which are required for assessing changes in the storage of groundwater in response to rainfall, evaporation, pump age, surface irrigation, soil conservation, urbanization, and a host of other causes. The area of upper vaigai river basin covering parts of Madurai and Theni districts, in Tamilnadu faces acute water scarcity and the area is chronically drought prone. The groundwater resources in the area are not fully exploited. The present investigation has been made to evaluate the potential zones for groundwater targeting using IRS – ID LISS – III geo coded data on 1: 50,000 scale. In this study groundwater prospective units and non potential areas were identified.

Khan and Moharana # (2002) studied on lithology, structure, geomorphology and hydrology were generated and integrated to prepare groundwater prospect map for a region in western Rajasthan. GIS was used to prepare database on the thematic layers, analysis of relationship and integrated map preparation. They observe the high, moderate, low potential zones in the study area.

Subba Rao et.al.,(2001) investigated the groundwater favorable zones around Guntur town. They assesed the groundwater favorable zones for development and exploitation with the help of geo-morphological units and associated features. The identification of features by remote sensing technology with the integration of conventional information and limited ground truths are PPS, L, PPM, PPD, and RH. The results shows that the PPD, PPM, PPS are good, moderate to good and poor promising zones, respectively for groundwater prospecting. They can also be utilized to augment groundwater resources.

Kumar and Tomar # (1998) carried out groundwater assessment through hydro-geo-morphological and geophysical survey. Remotely sensed data used to delineate the hydro-geo-morphological units. The correlation and integration of resistivity map with geo-morphological map were carried out through 'GRAM' Geographic Information System. This helped in better understanding the surface resistivity pattern. Resistivity zonation map prepared on the basis of limited field data and through interpolation / extrapolation can be modified / corrected with the help of information derived from remotely sensed data to obtain more realistic picture.

Tiwari and Rai (1996) studied groundwater prospecting in Dhanbad district of Bihar. Landsat – 5 MSS data of band – 2 and band – 4 and false color composite(FCC) of band 2, 3, 4 were interpreted visually to differentiate different hydro-geo-morphological units and to delineate the major trends of lineaments. The different geomorphic features identified are linear ridges, residual hills, pediplain, buried pediment and dissected pediplain, besides lineaments. The study shows that the pediplain and buried pediments are promising zones for groundwater prospecting.

Sarkar et.al., (2001) using GIS for generation and use of thematic information, applied to groundwater potentiality of the Shamri micro watershed in Shimla Tank. The role of various parameters, namely, drainage, lineament, lithology, slope and land use have been emphasized for delineation of groundwater potential zones. A multi – criteria evaluation following probability weighted approach has been applied for overlay analysis that allows a linear combination of weights each thematic map with the individual capability value. The result map indicates a high groundwater potentiality in the flood plains, river terraces and river channels in the vicinity of the Shamri nala. Other sites of high potentiality include places showing break in slopes and crisscross of lineaments.

Sankar et.al., (2001) studied on Hydro-morpho-geology and Remote sensing for groundwater exploration in Agnigundala mineralized belt (longitude $70^{0}.39^{1}$ – $16^{0}.51^{1}$ and latitude $16^{0}.2^{1}$ – $16^{0}.15^{1}$) using Remote Sensing IRS – IB and SPOT data for groundwater exploration. Based on erosional and depositional characters of various geomorphic units like Hills (structural and denudational) pediment, buried pediment, plains and valley fills have been identified in various lithologics like granite, granite gneiss, biotite schist, phyllite, quartzite and dolomite. The groundwater potentials of the individual geomorphologic units have been evaluated to obtain a complete hydrological picture of the area.

Obi Reddy et.al.,(2000) investigate the drainage, geology, geomorphology, lineament information has been generated and integrated to evaluate hydro–geo-morphological characteristics of the Gaimuk watershed, Bhandra district, Maharastra for delineation of groundwater potential zones. The analysis reveals that the deep valley fills with thick alluvium have excellent, shallow valley fills and deeply weathered pediplains in the geological formation of Tirodi Gnesis and Sausar Groups have good water potential and these units are highly favorable for groundwater exploration and development. The good interrelationship was found among the geological units, geo-morphological units, lineament density, hydro–geo-morphological zones and groundwater yield data.

Pratap et.al., (2000) investigate the Groundwater prospect zones in Data – Renukoot area in Sonebhadra district, U.P, India have been delineated, through integration of various thematic maps using ARC/INFO GIS. Each theme was assigned a weightage depending on its influence on the movement and storage of groundwater and each unit in every theme map is assigned a knowledge based ranking from 1 to 5 depending on its significance to groundwater occurrence. All the themes are overlaid, two at a time and the resultant composite coverage is classified into five groundwater prospect categories. This output map is correlated with the groundwater data collected in the field.

Pradeep K Jain et.al.,(1998) studied on to locate groundwater potential zones using IRS,LISS–II data. The resulting base line information has been integrated for evaluating groundwater potential of mapping units. The alluvial plain, flood plain, infilled valley and deeply burried pediplain are the prospective zones of groundwater exploration and development. Fractures and faults parallel to drainage courses constitute priority zones for groundwater targeting.

Khan and Ali (2002) studied the prospects of water resources in Gurgaon district (Haryana) and Alwar district (Rajastan) and suggest measures for optimal and conjunctive use of water resources assessed by remote sensing and GIS.

3.2. Soil and water Conservation Structures:

3.2.1. Soil conservation structures:

Soil and water conservation, one of the components of watershed management, receive top priority as they are prerequisite for the watershed development. Soil and water conservation structures such as bunds , waterways , grade stabilization structures, erosion structures and water harvesting structures are generally constructed in the watershed in order to check the soil erosion and maximize utilization of excess runoff for the crop production.

The main aims of soil conservation structures are: -

- Productivity per unit area per unit time per unit water creating adequate production for the soil susceptible to erosion during rainy season.
- Conserving as much rainwater as possible at the place where it falls in order to increase groundwater recharge.
- Draining out the excess water safely and storing excess runoff for reuse for future need.
- To control fully formation to bring the revine denuded land under cultivation by constructing diversion drains and check dams at suitable intervals.

3.2.2. Water Harvesting Structures:

Supplemental irrigation at times becomes essential for survival of horticultural and agricultural crops in drought – prone areas with undependable and erratic rainfall. In order to accomplish this, excess rainwater has to be conserved in soil profiles and in different storage structures.

3.2.2.1. Farm Ponds :

Form ponds are bodies of water, made either by constructing an embankment across a watercourse or by excavating a pit or the combination of both.

Objectives:

To provide water storage for life saving irrigation in a limited area.

To provide drinking water for live stock and human beings in arid areas.

To serve as water storage for providing critical irrigation to limited number of fruit plants for establishment moderate the hydrology by small watersheds.

To increase groundwater recharge.

Specific site conditions:

Excavating pits in areas having flat topography and mostly in situations where table close to the ground level generally creates dugout ponds. On the other hand, impounding type of form ponds are common features. Wherever there are well – defined water ways with rolling type of topography, it is possible to achieve high water storage – earth work ratios with embankments / bunds constructed in narrow and deep valleys, while the ponds constructed by excavation only have this ratio mostly less than unity. In the case of impounding type, preference is given to locations with – low soil permeability.

Design criteria:

Farm pond size is decided on the total requirement of water for irrigation, live stock and domestic use. If the precipitation in the region is very low, the capacity of pond will only include the requirement for live stock and domestic use. Design features of the embankment type ponds are governed by physiography, excavated ponds may be constructed either square or rectangular in shape.

3.2.2.2. Minor irrigation Tanks / Low Earthen Dams :

Low earthen dams, designed on the basis of engineering principles, are constructed across the streams for creating water reservoirs for providing one or two irrigation to the crops at the critical period.

Objectives:

To provide irrigation source for the crops grown under its command. For mitigation of draught by providing much more needed water.

Design criteria and procedures:

Following aspects are considered as basic requirements for designing the earthen dams. Hydrologic data, information on soils and geology, the nature and properties of the soils in the area, profile survey and cross sectional details of the stream. In order to arrive at proper design of the earthen dam site selection is very important. As for as possible, a narrow gorge should be selected for erecting the dam in order to keep the ratio of the earthwork to storage at minimum. Runoff availability for the reservoir should be compiled on the basis of rainfall – runoff relation for the locality.

3.2.2.3. Water harvesting Bundhis:

In many respects, water harvesting bundhis are similar to minor irrigation tanks except that they generally do not have extensive canal system and their command area is limited to fields lying to the bundhis of the down stream.

Objectives:

To collect and impounds surface runoff during monsoon rains and facilitate infiltration to raise groundwater level in the zone of infiltration of the bundhi.

Specific site conditions:

As for as possible the water harvesting bundhis should be located in government lands. They should not be located on very heavy soil or impervious strata, which may hinder groundwater recharge. There should be adequate good cultivated land at the down stream of bundhi to reap the benefits of water storage. Bundhi should be located in places where adequate good quality of soil is available for bunds construction.

Design criteria:

The design criteria of the water harvesting bundhis are the same as those small earthen dams. The runoff availability is based on strong table as discussed in the case of minor irrigation tanks. Emergency spillway, mechanical spillway and slice gates are also designed on similar principles. In general, bund sections are smaller than those of irrigation tanks.

3.2.2.4. Nala Bunds and Percolation tank:

Nala (a natural watercourse) bunds and percolation tanks are structures constructed across nalas for checking velocity of runoff, increasing water percolation and improving soil moisture regime. In fact, both terms are synonyms although used alternately at different places. However bigger structures that costs five lacks or more are generally called percolation tanks.

Objectives:

To facilitate improving use of runoff donated by a catchment and to encourage underground percolation of stored water with a view to build up groundwater level in the zone of influence of nala bund / percolation tank. To hold the silt flow, which would otherwise reach the multi – purpose reservoirs and reduce their useful life.

Specific site conditions:

The feasibility of the site for locating a nala bund depends upon the following technical and economic considerations. The site should be selected in relatively flatter nala reach – the slope not exceeding 2%. As for as possible, the catchment area of the nala bund should be at least 40 hectares. There should be proper site for construction of emergency spillway by the side of the nala bund. For this, the substrata of the nala bund should be hard enough, preferably hard rock, and the nala bed should have soils with adequate permeability. If there are rocky layers at greater depths, they should be designated ones.

Design:

The design is based on topographic and storage – height considerations. With these criteria nala bund sections are designed in the light of local norms prescribed for the, structures. In general, the top width of nala bund should not be less then 1.0m. A free board equivalent to one – third of the impounding depth but not less then 1m, is provided. The bund section should include provisions on core wall and pebble trench on the line indicated for earthen dams. An emergency spillway of cut outlet type may also be provided depending upon the drainage area.

3.2.2.5. Check Dams:

Stop dams are permanent engineering structures created for rising the water level in the nala for providing life – saving irrigation to the surrounding fields and also in controlling the erosion of the soil by decreasing the velocity of water which is coming with great speed from the upstream side.

Objectives:

To provide storage of surface runoff during the runoff availability period for sub sequent irrigation. To hold a part of the floodwater during peak periods so that there is no damage at the down stream of the gully due to excessive erosion of the flood. To provide adequate infiltration opportunity for rainwater for recharging groundwater.

Specific site conditions:

Check dams are created in relatively float nalas having narrow cross section but carrying high discharges for fairly long durations. There are located at sites where stable foundation conditions of hard murram or rocks, are encountered, where topography is not suitable for other structures.

Design criteria and procedures:

The essential components of a stop dams are head wall extension sidewalls, apron, wing walls, toe wall, and seepage out – off walls. The structures are designed to accommodate peak design discharge of 100 years recurrence interval. The main head wall is designed by providing adequate margin of safety and the gravity dam section is particularly checked against the following failures:

(a) Over turning of the wall.
(b) Crushing of the foundation.
(c) Tension at the base of the dam.
(d) Risk of sliding of the dam.

In addition to these, allowances on other safety factors like failure due to piping bellow the foundation and failure due to seepage uplift pressure are also provided.

The design conditions are carried out with two main conditions, i.e. reservoir full and reservoir empty. In general, the bottom width of the main dam should be nearly 2/3 of the height of the dam.

3.2.2.6. Rock-fill Dams:

A Rock-fill dam – an embankment constructed across a waterway using variable sizes of stones or over burnt bricks – is usually a permeable type of semi – permanent structure, such as a loose / stone checks are generally adopted for gully control.

Objectives:

For gully control to slow – down the velocity of runoff and to induce some sedimentation before it leaves for the down stream reach.

1. To facilitate reclamation of board and shallow gullies for agricultural purpose, provides the runoff discharge are with in limits.

2. To stabilize active gullies by encouraging vegetative growth because of favorable moisture situation created by impounding water.

Specific site conditions:

Rock-fill dams are constructed in places where loose boulders are locally and cheaply available and gullies are not wider than 10m or so. Brick dams usually replace those dams if good quality bricks are cheaply available. In case foundation conditions are highly unstable, gabions are preferred in place of ordinary rock-fill dams.

By and large, rock-fill dams require better foundation conditions than the earthen dams or earthen gully plugs.

CHAPTER – 4

METHODOLOGY

4.1. General

Groundwater prospecting and exploration have become a big task in India in general and certain drought stricken areas in particular. The photo – interpretation of aerial photographs and satellite imageries on different IRS bands have been proved to be of very special value in providing data on parameters which are essential in judging the groundwater status of a region. The parameters include the nature and distribution of vegetation, soil cover, drainage pattern and density and their temporal variations. In addition, information on other important aspects like the nature of rock types, their structural altitude and geo-morphological relationships, occurrence of faults, fractures, fissures major drainage controls, shifts in spring lines and variation in the water levels in the surfacewater bodies provide important clues in the search for groundwater bodies. The identification of grounds, sands and alluvium in the river valleys, and other water bearing rock formations in the hard rock terrain helps in locating groundwater potential zones. The success of drilling for groundwater entirely depends on the prospecting exploration data obtained by the field surveyors. To help them to achieve results in a short time with low expenditure, groundwater exploration needs to be based on the technique of photo – interpretation using aerial photographs and satellite imageries. The detailed exploration in promising areas is to be supplemented by geophysical techniques and other ground data collected in the field.

Image interpretation has been defined as the act of examining photographs / images for the purpose of identifying objectives and judging their significance. Interpreters study remotely sensed data and attempt through logical process to detect, identify, measure and evaluate the significance of environmental and cultural objectives, patterns and spatial relationships.

The False Color Composites of PAN and LISS – III merged image data has been prepared and interpreted with limited field check. For preparation of 1998 groundwater prospect map MSS image are used. Besides this the available literature on the subject is also consulted.

4.2. Geo-coding of toposheets :

Digitally converted toposheets are projected with standard reference scheme. The projection considered here are polyconic and spheroid taken is Everest and datum as undefined. The geometric model taken is polynomial of first order and the geo-reference points given from keyboard. Projected toposheets were digitally mosaicked to obtain one contiguous geo-reference topobase in the digital mode.

4.3. Image Enhancement:

Geometrically corrected images were further subjected to radiometric correction to generate FCC. This process has been done as follows:

To perform contrast-stretching operation, the first step is to plot histogram of the DN values in the image. This itself conveys valuable information about the image. A sharp peak would indicate no contrast in the image, and a broad distribution would imply objects of high contrast.

4.4. Available Data: -

The data pertaining to groundwater is collected by Andhra Pradesh state groundwater department. This data is used for assessing the groundwater level fluctuations in the study area.

The thematic maps are prepared and the data utilized for the purpose are as below:

- LISS - III and PAN merged data.
- MSS image.
- Topo-sheets of the study area.

4.5. Preparation of Thematic Maps :

Image interpretation is the act of examining the photographic or other imagery for the purpose of identifying objects and judging their significance. The main objective of image interpretation is to extract information about features displayed in an image. The extraction of information depends on image analyst's experience, power of observation, imagination and patience. It all depends on the basic principles of image formation, and the scale and resolution of the imagery. A typical remotely sensed image is an instantaneous record of features on the ground. It may have taken only 1/500 second to record the image in the case of an aerial photograph or about 30 second in the case of satellite. An image is permanent record at a point in time. The synoptic view provided is of great importance in detecting large-scale features and understanding their inter-relationships.

The major step involved in the image interpretation is quick look analysis of the imagery wherein an interpreter takes into consideration the following points:

- Selection of proper spectral bands
- Time of the imagery
- Marking study area from base map
- Stratification taking into consideration statistical and ecological needs.

Visual image interpretation techniques are applied for the preparation of geo-morphology, land use/ land cover, slope, soil, lineament maps. The help of Survey of India Toposheet is taken for preparation of base map and thematic maps.

1. Base map
2. Drainage map
3. Slope map
4. Land Use / Land Cover map
5. Hydro geomorphology map
6. Well (bore and open) location map

7. Lineament map
8. Geology map
9. Groundwater prospect map, 2002.
10. Groundwater prospect map, 1998.
11. Groundwater recharge structure map.

The steps involved in the preparation of thematic maps are as follows:

Preliminary interpretation.

Data collection,

Preparation of general groundwater prospecting map.

4.5.1. Base Map:

The base map is prepared from SOI toposheet. The base map contain the details like road network, villages, tanks, boundary of the study area, telephone and power line etc. Using base map to prepare various thematic maps like

- Land use / Land cover map
- Slope map
- Geomorphology map etc

The base map contains settlements, road networks, rivers, railway track etc. on the toposheets are used for exact matching with satellite imagery. The base map was prepared from SOI toposheet No. 56L/1 & 2.

4.5.2. Drainage Map :

The drainage map was prepared from toposheet. The drainage pattern usually classified as

1. Dendritic
2. Rectangular
3. Parallel.

4. Sub parallel
5. Radial
6. Centripetal.

Factors vary from one drainage basin to another in such a manner that no two drainage basin are alike. Linear aspects of drainage basins are:

a) Drainage network pattern.
b) Stream order.
c) Bifurcation ratio.
d) Stream frequency.
e) Length of over – land flow.

A. Drainage network pattern:-

Drainage pattern usually classified as dendritic, rectangular, trellis, parallel, sub parallel, radial and centripetal

B. stream Order: -

In Horten System of stream ordering first order streams are defined as those streams that have no tributaries. Two such first order streams combine to form second order streams. A third order stream is formed by merging of two second order streams. The ordering system continues in the same manner.

C. Bifurcation Ratio: -

It is defined as the ratio of streams of a particular order to that of subsequent higher order.

$$R_b = N_u / N_u + 1$$

Where, Rb = Bifurcation ratio and N_u = Number of streams of given order.

Bifurcation ration characteristic ranges between 3 and 5 for watersheds in which the geologic structure do not distort with drainage pattern. High bifurcation ratio expected in the regions of steeply dipping rock strata where narrow strike valleys are confined between ridges.

4.5.3. Slope Map:

Slope is the measure of the amount of the rise divided by the amount of horizontal distance traveled. Slope map is used to know the terrain properties like steep slopes and plains. The speed and extent of runoff depends on the slope. The velocity of runoff flow increases with increases in slope. The erosion capacity of runoff varies in – direct proportion with the slope of the land on which runoff occurs. The soil erosion also increases with increases in slope.

The preparation of slope map is very useful for watershed management, groundwater resources, and land use and land cover.

The distance between successive contours as measured on plany-metric maps indicate the nature of the slope. Contours are made at rectangular intervals but they do not appear equidistant when viewed vertically. They come close together when slopes are steeper.

Slope is classified as seven classes. They are nearly level, very gentle sloping, gently, moderately, strongly, moderate steep to steep, very steep.

Slope classification:-

S.No	Classification of slope	Min.& Max. limits of slope %	Min. & Max. limit of contour spacing
1.	Nearly level	0 – 1	>4cm
2.	Very gentle sloping	1 – 3	1.33 - 4 cm
3.	Gentle sloping	3 – 5	0.8 - 1.33 cm
4.	Moderately sloping	5 – 10	0.4 – 0.8 cm
5.	Moderate to steep slope	10 – 15	0.26 – 0.4 cm
6.	Steep slope	15 – 35	0.11 – 0.26 cm
7.	Very steep slope	>35	<0.11 cm

The slope map is prepared by toposheet based on density of contours. The slope map is classified by upper and lower limit of contour space. Nearly level slope classification is predominantly occurring slope in the watershed.

The slope present is calculated by the formula

$$Slope\ \% = H / L * 100$$

Where H is the height and L is the length.

Slope in the 2 to 6 % range are steep enough to provide for good surface drainage and few significant site development problems will be encountered provided the soil is well drained. The class 1 and 2 (0 – 3 %) in the prepared slope map some drainage problems may be en countered. Slope over 12% presents problems in street development and lot design and also pose serious problems when septic tanks are used for domestic sewage disposal.

Slops of not more than 5 % are preferred for industrial park and commercial site. The site plan in the 6 to 12 % range may be more interesting than the 2 – 6 % range but will be more costly to develop. Groundwater table is observed in class 1 because it is nearly level.

4.5.4. Land use / Land cover Map:

A preliminary interpretation key is prepared and later finalised after limited ground verification.

There are certain fundamental photo-elements or image characteristics seen on image which laid in visual interpretation of satellite imagery. There are number of elements are used for identification of land features. Those are –

i) tone or color ii) size iii) shape iv) texture v) pattern vi) location vii) association viii) shadow ix) aspect x) resolution.

Land use / Land cover are classified in to six classes. Those are Built-up land, Agricultural land, Forest, Waste lands, Water bodies, others.

1. Built-up land:

Built-up land comprises of developed areas like buildings, industrial structures, transportation network etc. The physical size or build-up sprawl with transport network can be surrogate to classify a settlement as urban or rural. It is identifiable on the imagery by its dark bluish tone, definite size, shape and texture. Often built-up land with high density of buildings etc. appear in dark tone at the centre and lighter on the peripheries, because of being less dense and less developed. Transport network appear in shades of dark bluish green to light yellow (unmettled or kaccha roads) to red (wherever vegetation occurs along the road) in color.

2. Agricultural land:

   This is sub-devided into crop land, fallow land, plantation.

   a. Crop land:

      The tonal contrast of crop land varies from bright red to red which may signify greenness of the foilage different stages of crop growth.

   b. Fallow land:

      It appears yellow to greenish blue in tone depending on the topology, nature of soil and moisture content on ground. It appears light in tone sandy red soils and in coastal soils and dark in tone in alluvial black cotton and in soils rich in clay.

   c. Plantations:

      These appear in dark red to red in tone, small in size with regular shapes and sharp and smooth edges.

3. Forest:-

   This can be sub- devided in to evergreen/ semi- evergreen forests, deciduous forest, degraded or scrub land, forest blank, forest plantation, mangroves.

   a. Evergreen/ semi- evergreen forests:

      These appear in bright red to dark red in tone in all months of the year.

   b. Deciduous forests:

      It is observed dark red to red in tone (during maximum greenness period) except during the month of leaf fall in dry season/ autumn when the tonal changes occur.

   c. Degraded or scrub land:

      It appears light red to dark brown in tone.

d. Forest blank:

Forest blanks appear distinctly on the imagery in light yellow to light brown tone, small in size with regular to irregular shapes.

e. Forest plantations:

It appears light red to red in tone depending upon the foliage cover stage of growth and season etc.

f. Mangroves:

It appears bright red to red in tone, small in size with irregular and discontinuous shapes, smooth to medium in texture, and contiguous to linear.

4. Waste lands:

This can be sub- divided into salt affected land, waterlogged land, marshy/swampy land, gullied / ravinous land, land with or without scrub, sandy area, barren rocky/stony waste/sheet rock area.

a. Salt affected land:

It appears white to light blue (subject to moisture content) tone, small to medium size, irregular discontinuous shape.

b. Waterlogged land:

Light to dark blue (subject to water spread and organic matter)varying in size, irregular, discontinuous shape.

c. Gullied/ ravonous land:

It appears light yellow to bluish green, irregular broken shape.

Land with or without scrub: Light yellow to brown to greenish blue, varying in size, irregular discontinuous shape.

d. Sandy area:

White to light yellow blue tone, regular to irregular shape.

e. Barren rocky land:

Greenish blue to yellow to brownish, irregular and discontinuous shape.

5. Water body :-

It is appear in black color, irregular shape.

Land use / Land cover base map is prepared from SOI toposheet base map. The base map is placed on satellite imagery and the only outlet is determined and all built – up land, Agricultural, land forest, waste lands, water bodies are recognized.

4.5.5. Geomorphological Map:

Basic theory behind hydrogeomorphological map preparation is as follows:

a. Principles of landform identification:

The principle terrain characteristics estimated by means of image interpretation are bedrock type, landform, soil texture, site drainage conditions, susceptibility to flooding and depth of unconsolidated materials over bed rock. In addition, the slope of the land surface can be estimated by image interpretation.

b. Elements of image interpretation for landform identification and evaluation:

Image interpretation for landform identification and evaluation is based on systematic observation and evaluation of key elements. These are topography, drainage pattern and texture, erosion, photo tone, vegetation and land use.

Geo-morphological mapping will always require a considerable amount of field exploration, but the mapping process can be greatly facilitated through the use of visual image interpretation. Geo-morphological units identified are pediplain shallow, pediplain medium, pediment, and residual hills.

Pediment zone is erosional land form of low relief, covered with a thin veneer of detritus material and acts as runoff zone, which bears moderate to poor prospects of groundwater. In Geo-morphology map observe the lineament intersection with in the pediment zone, it is indicate the potential site for the groundwater development.

Residual Hills act as run – off zone and groundwater prospects in these hills seem to be very poor.

4.5.6. Well Location Map:-

Well location map was prepared by using wells latitude and longitude. This map contain open wells and bore wells. This data are collected by field work using GPS. And this well location map contain particular well details like depth, pumping datum, water level depth, type of well, age of the well, well condition etc.

Well Inventory:

Well inventory was conducted in the open wells by observing the well cross sections and lithology of the various bore wells and dug wells. These information were collected from the well owners. Well depth, water level below ground level, water level fluctuations and yielding capacities of the individual well given in table.

4.5.7. Lineament Map:

Structurally the rocks are folded, faulted and sheared to varying degree in the study area. Major lineaments were marked on the image based on tonal variation and drainage pattern. The following facts are involved in the interpretation of all these three types of faultes from the satellite image:

a) The crushed or brecciated zone lying between two moving rock blocks is often marked by straight stream course offset distance and again follows the straight course. Bending and dragging beds are common.
b) As the same case above, when two ridges are offset to a small distance by a fault plane.
c) Fault scarps are most conspicuous and common indications of young and reactivated faults.
d) Fault blocks result in multiple scarping and they give rise to step like topography.

e) Abrupt truncations or terminations of landforms, lithology, geological structures, drainage patterns etc. along a straight line are common indications at faulting.

f) The physiographic criteria include offset ridges, scarps, scarplets, modified drainage patterns and alignment of springs, vegetation, etc.(Pandey, 1987).

Lineament map was prepared from geo-morphology and geology maps. This map was prepared based on types of rocks and structures. Lineament map can be divided in three types based on lineament density. Those are poor, moderate and high density lineaments.
This map was prepared by NRSA.

All the thematic maps were scanned by HP SCAN Z-2 scanner, this scanned data are digitized in AUTO CAD 2000 using polyline, erase etc. commands. This digital data are exported to ARC/INFO.

4.5.8. Groundwater Prospect Map:

All the thematic maps were integrated by overlay technique using a logical classification of groundwater prospect. The methodology is –

Preparation of 'Coverage':-

The first step in any GIS operation is registered with reference to a base map and after editing input into ARC/INFO GIS database as separate layers or 'Coverage'. For each thematic map, topology was created by using 'CLEAN' and 'BUILD' in ARC/INFO. Lineaments were buffered for 20m to make them polygons.

Overlay and classification of prospect classes:-

All the 'coverage' themes are overlaid, one at a time, using UNION in ARC/INFO to generate a composite map. The attribute table of each composite coverage is associated with a particular set of lithology, landform, slope. etc. The evaluation of groundwater prospect of each polygon in the output is based on the added values of scores of various themes.

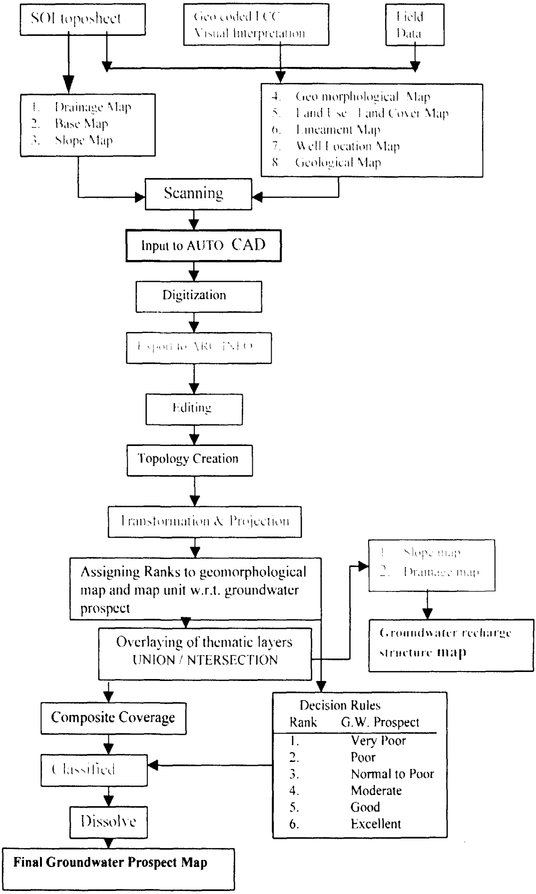
This output map was reclassified into five categories of groundwater prospect from 1 to 5. All the polygons having the same prospect class were merged using 'Dissolve' operation.

Groundwater prospect maps 1998 and 2002 are prepared using above procedure.

4.5.9. Groundwater recharge structure map:

This map is prepared by overlaying of slope map and drainage map. Based on slope percentage locate the groundwater recharge structures.

Schematic diagram of the approach



Topographical conditions and slope play a vital role in availability of groundwater(Subba Rao,1992. Venkateswara Rao, 1998). In the present study assessment of groundwater potential zones is carried out considering the necessary steps.

Using PAN and LISS – III merged data and field data are using following data are generated.

5.1. Base Map:

In base map different features are observed those are settlements, water bodies, road and rail network, telephone, power line, open scrubs, scrub forest, wells and trees. Those features are shown in Fig : 5

5.2. Drainage Map:

Drainage network contain up to 3rd order. The bifurcation ratio value are below 4, it can be indicated that the soil erosion is less in these area and the geological formation are not disturbed.

The drainage pattern is dendritic and texture is coarse. Drainage map are shown in Fig : 6

Fig. 5

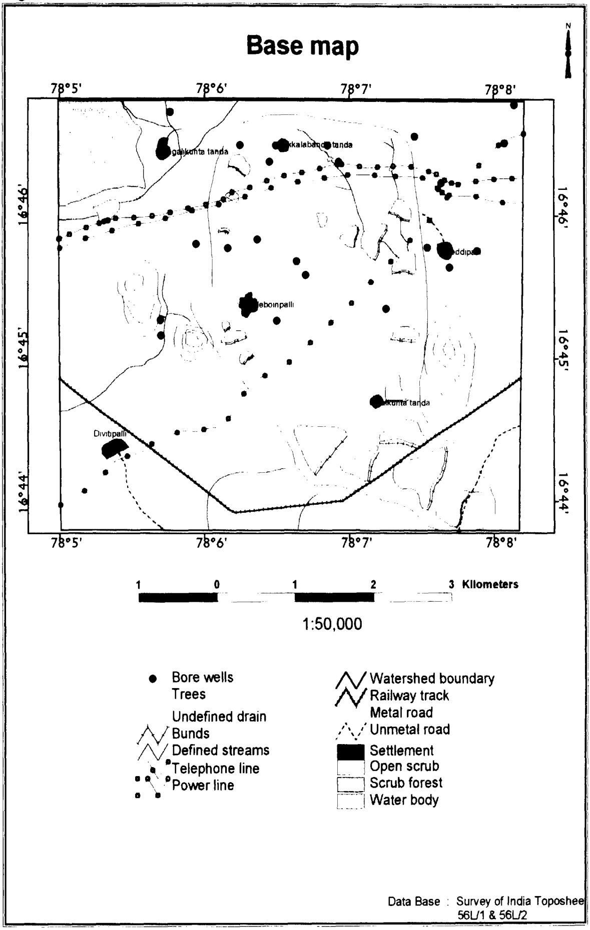
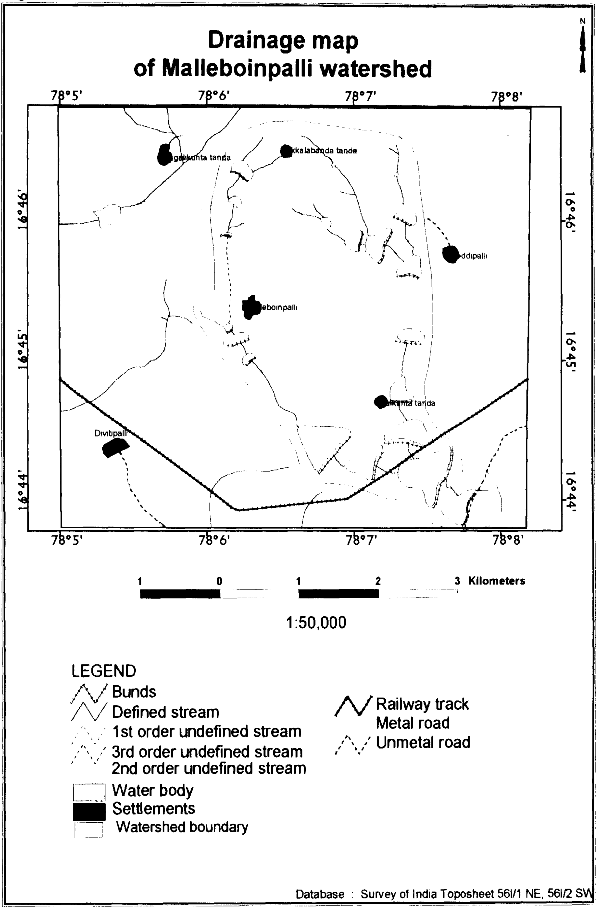

Base map
N
78°5'
78°6'
78°7'
78°8'
16°46'
16°45'
16°44'
tanda
eboinpalli
Divitipalli
1 0 1 2 3 Kilometers
1:50,000
Bore wells
Trees
Undefined drain
Bunds
Defined streams
Telephone line
Power line
Watershed boundary
Railway track
Metal road
Unmetal road
Settlement
Open scrub
Scrub forest
Water body
Data Base : Survey of India Toposhee
56L/1 & 56L/2

Fig. 6



Drainage map
of Malleboinpalli watershed
N
78°5'
78°6'
78°7'
78°8'
16°46'
16°45'
16°44'
ta tanda
kalabanda tanda
ddipalli
eboinpalli
tanda
Divitipalli
1
0
1
2
3 Kilometers
1:50,000
LEGEND
Bunds
Defined stream
1st order undefined stream
3rd order undefined stream
2nd order undefined stream
Water body
Settlements
Watershed boundary
Railway track
Metal road
Unmetal road
Database : Survey of India Toposheet 56I/1 NE, 56I/2 SW

5.3. Slope Map:

Seven classes of slope are identified in the study area. They are-

S.No.	Classification of slope	Min.& Max. limits of slope %	Min. & Max. limit of contour spacing
1.	Nearly level	0 – 1	>4cm
2.	Very gentle sloping	1 – 3	1.33 - 4 cm
3.	Gentle sloping	3 – 5	0.8 - 1.33 cm
4.	Moderately sloping	5 – 10	0.4 – 0.8 cm
5.	Moderate to steep slope	10 – 15	0.26 – 0.4 cm
6.	Steep slope	15 – 35	0.11 – 0.26 cm
7.	Very steep slope	>35	<0.11 cm

Table :3

a. Nearly level sloping:

Groundwater table is observed in class one because it is nearly level. Maximum and minimum slope is 0 – 1 %.In this level contour spacing is >4cm, nearly level occupy 6.558 km^2 in the study area. In nearly level slope percentage in the study area are 18.80 which indicate that runoff is very low, groundwater recharge is very high.

b. Very gentle sloping:

In this class some drainage problems may be encountered. In this class groundwater recharge could be slightly low. This area occupy 17.974 km^2 in the study area. Groundwater potential is low compared to nearly level sloping. In this class contour spacing is 1.33 to 4 cm.In the study area 51.30% of area is occupied by very gentle sloping.

c. Gentle sloping :

In this class surface drainage is good. Soil erosion takes place in this gentle sloping. This area occupy 4.776 km^2 in the study area. Minimum and maximum limit of contour spacing is 0.8 to 1.33cm, it indicate in this area runoff is very high and groundwater recharge is low compared to very gentle sloping. In the study area 13.60 % of gentle slope land occurred.

D. Moderately sloping:

In this class drainage problems occur. Groundwater potential is low. This class occupy 2.914 km^2 in the study area. Percentage wise moderate slope land in the study area is 8.30%.

e. Moderate to steep sloping:

In this class maximum and minimum limit contour spacing is 0.26 to 0.4 cm. In this area runoff is high and groundwater recharge is low. In this class occupy in hilly areas. This class occupy 1.442 km^2 (4.10%) in the study area.

f. Steep slope:

In this class soil erosion is high and runoff also increases. This class occupy 0.988 km^2 (2.85%) in the study area.

g. Very steep :

In this class runoff is very high groundwater recharge is very poor. Groundwater potential is very poor. This class occupy 0.358 km^2 (1.10%) in the study area.

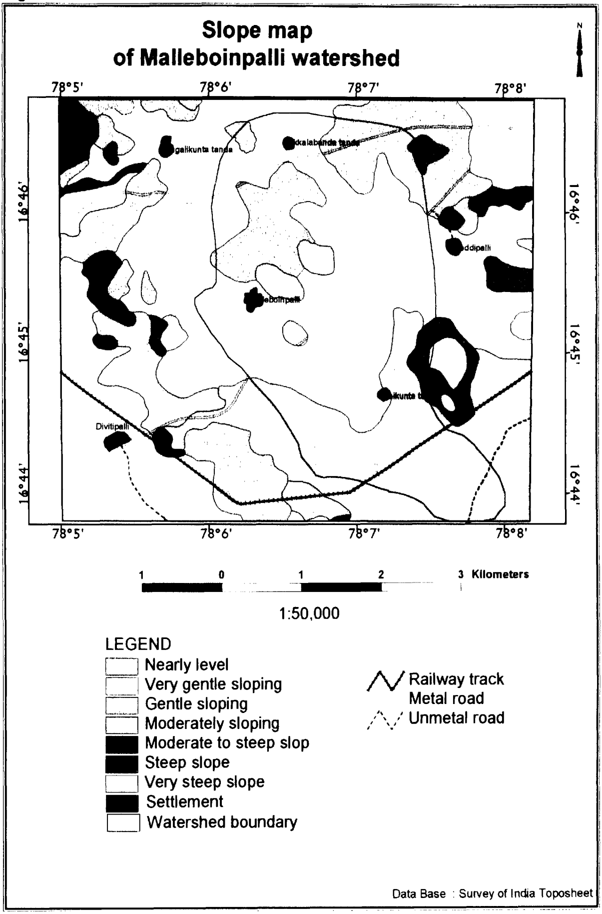
Study area statistics –

Slope class	Area in km^2	Area %
Nearly level sloping	6.588	18.80
Very gentle sloping	17.974	51.30
Gentle sloping	4.776	13.60
Moderately sloping	2.914	8.30
Moderate to steep sloping	1.442	4.10
Steep sloping	0.998	2.80
Very steep sloping	0.358	1.10
Total -	35.05	100.00

Table : 4

Slope map is shown in Fig : 7

Fig. 7


Slope map
of Malleboinpalli watershed
N
78°5'
78°6'
78°7'
78°8'
16°46'
16°45'
16°44'
galikunta tanda
ddipalli
Divitipalli
1 0 1 2 3 Kilometers
1:50,000
LEGEND
Nearly level
Very gentle sloping
Gentle sloping
Moderately sloping
Moderate to steep slop
Steep slope
Very steep slope
Settlement
Watershed boundary
Railway track
Metal road
Unmetal road
Data Base : Survey of India Toposheet

5.4. Land use / Land cover Map:

PAN and LISS-III merged image are used to prepare Land use / Land cover map.
In the study area 5 types of land use is observed.

Level -I	Level –II
a. Built-up land	Built-up land (Village)
b. Agricultural land	i) Kharif, un-irrigated(KU) ii) Double Crop (DC)(Kharif + Rabi) iii) Fallow (F)
c. Forest land	Scrub forest (SF)
d. Waste lands	i) Land with scrub (LS) ii) Land without scrubs(LWS) iii) Barren rock/Stony waste/Sheet Rock area (BSA)
e. Water bodies	Lake/Tank/Canal

Base map is prepared from SOI toposheets. The base map is placed on satellite imagery to delineate built – up land, agricultural, forest land, waste lands, water bodies are recognized.

Image elements to interpret Land use/ Land cover of the study area

LU/ LC category	Tone	Size	Shape	Texture	Pattern	Location	Association	Season
Built-up land	Dark bluish Green	Small to big	Irregular disconti-nuous	Coarse and mottled	Clustered to scattered and Non-continuous	Plains, Plateaus, on hill slopes, road, rail etc.	Surrounded by cultural lands, wastelands etc.	October to March
Crop land	Bright red	varying in size	Regular to irregular	Medium to smooth	Contiguous non-contiguous	,,	Irrigated and un-irrigated etc.	June to September Oct to March
Fallow land	Yellow to Greenish Blue	Small to large	,,	,,	,,	Plains, valleys uplands etc.	Harvested agricultural land etc.	January to December
Scrub land	Light red to dark brown	Varying in size	irregular disconti-nuous	Coarse to mottled	contiguous non-contiguous	Mountain slopes, isolated hill foot slopes etc	Hill slopes skeletol etc.	January to December
Land with or Without scrub	Light yellow to brown to Greenish blue	,,	,,	,,	Contiguous dispersed in patches	Terrain with varying lithology and landforms	Gentle relief with moderate slope in plains etc	October to March
Barren rocky/ Stony waste/ Sheet rock area	Greenish blue to yellow to brownish	,,	,,	very coarse to coarse medium	Linear to contiguous and dispersed	steep isolated hillocks etc.	mined areas quarried sites boulders	January to March

Built-up lands mainly surrounded by cultural lands and wastelands. In the study area 0.218 Km^2 area are occupied by residences. There are no industries and multi constructions in the study area. It is a rural area. In built-up lands permanent huts and temporary huts are observed. 0.65% of built-up lands in the study area.

Large area of Kharif un-irrigated lands occupied 26.033 Km^2 (74.20%). It indicate the large area are mainly depend on rainwater. Double croping area are less in the study area, it is 7.25%. In the Malleboinpalli area rainwater and groundwater is the main source for irrigation.

Rocky area occupy 5.25% in the study area. In this area groundwater potential is poor. The surrounding of the hills, suitable for groundwater harvesting.

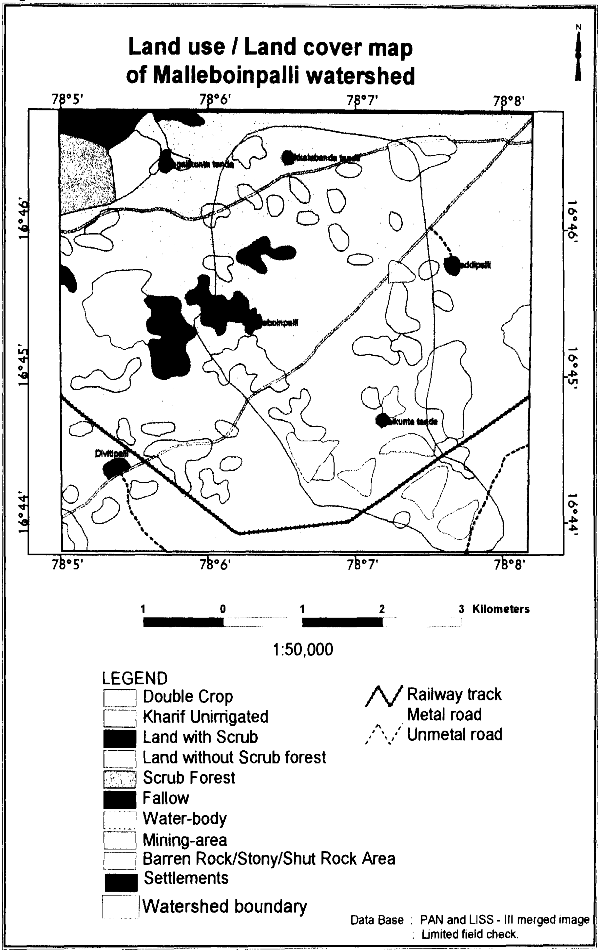
Area statistics –

LU/LC	Area km^2	Area %
Built-up land	0.218	0.65
Double crop	2.532	7.25
Kharif unirrigated	26.033	74.20
Land with scrub	1.283	3.65
Land without scrub	1.294	3.75
Fallow land	0.164	0.45
Scrub forest	0.624	1.70
Barren rocky/stony/sheet rock	1.807	5.25
Mining area	0.116	0.35
Water body	0.962	2.75
Total -	35.05	100.00

Table :6

Land use / Land cover map shown in Fig :8

Fig. 8



Land use / Land cover map
of Malleboinpalli watershed
N
78°5'
78°6'
78°7'
78°8'
16°46'
16°45'
16°44'
1 0 1 2 3 Kilometers
1:50,000
LEGEND
Double Crop
Kharif Unirrigated
Land with Scrub
Land without Scrub forest
Scrub Forest
Fallow
Water-body
Mining-area
Barren Rock/Stony/Shut Rock Area
Settlements
Watershed boundary
Railway track
Metal road
Unmetal road
Data Base : PAN and LISS - III merged image
: Limited field check.

5.5. Geomorphology:-

The study area is characterized by a number of erosional and depositional features. The landforms representing the erosional process are mainly denudational hills- inselburgs, pediments etc. Some of the hills have undergone erosional process but their structural trends are distinctly exhibited. These are identified as residual hills. Depositional process as have developed land forms namely pediment, valley fills etc. The weathered pediment some times buried under soil cover represent the features formed by the involvement of both erosional and depositional process.

Geomorphic units have been presented under three different heads :

- hilly terrain
- inter mountain valley, and
- plain areas.

Hydrogeomorphological units in the hilly terrain:

a. Inselburgs :

Isolated hillocks of granite inselbergs have been identified which are mainly formed with the granite near Bureddipalli village. This unit is acting as a surface runoff facilitating due to its slope. Groundwater potential is very poor. 0.635 Km^2 (1.85%) area is covered by inselburgs in Malleboinpalli area

b. Residual hills:

These residual hill (RH) unit consists of Granites. These form prominent strike ridges and valleys. Residual hills have been identified near Mangalikunta Thanda, Malleboinpalli village and Bureddipalli village. Ridge part mainly forming anticlinal hills and synclinal part is forming narrow valleys. Groundwater potential in this unit is poor, but narrow valleys often contain springs and seepages, suitable for dugwells and wells. 1.560 Km^2 (4.45%) area of residual hills in the Malleboinpalli area.

c. Pediment:

Lithologically these units are composed of granites, often covered by thin layer of soil, occurring mostly at the base of the hills. Pediments are mainly occupied near Mangalikunta Thanda and Malleboinpalli village. Groundwater prospects in these zones can be considered as normal to poor, but presence of lineaments or fractures provide some scope for movement of groundwater and hence suitable for groundwater prospecting.Pediment 9.85% (3.447 Km^2)in the study area.

Hydrogeomorphological units in Inter-mountain valley:

The valley fills, identified in the study area and developed in litho unit. This unit occupies the lowest reaches in topography and composed mainly of boulders, pebbles, sand, silt and other detrital material. This has very good porosity and permeability but some presence of clay may make it impermeable. However, these units are considered to be potentially good for groundwater.

a. Valley fill:

Valley fill have been observed over granite and granite gneiss. This units is mainly composed of boulders, pebble's, sand, silt etc. Groundwater conditions in this unit are excellent and groundwater is exploited through dug wells and bore wells.Valley fills are 0.45% (0.163 Km^2) in the study area.

Hydrogeomorphological units in the plain areas:

Pediments with more or less over burden of accumulated materials on the shallow to deeply weathered rocks have been identified in various lithologies. The extent of weathering and examined during field work. Extent of weathering and burial nature is based on field observations in different rocks are described below-

a. Pediplain with moderate weathering:

Schistose rocks and biotite granite characterize the area. These formation of moderately weathered pediment which has a gently undulating topography with less than 15m thickness. This unit is characterized by purely unconsolidated alluvial material made up of rock debris and soil deposited over pediment. This unit occupy 21.65% (7.588 Km^2) in the study area. These units are suitable for dug wells and shallow bore/ tube wells because of their good potential with sustained yield. Depth of water level during 2002 period ranges from 14.5 to 15.7 mbgl and during 1998 period ranges from 15 to 16.7 mbgl. Average depth to water level of domestic well varies from 15.6 to 16.4 mbgl.

b. Pediplain with shallow weathering:

Shallow weathered pediment is developed in medium to coarse grained biotite granite. Which occur near Mangalikunta Tanda, Bureddipalli and Malleboinpalli village. It consists of unconsolidated alluvial material made up of rock debris and soil thickness of 0 to 5m with constant recharge from streams offering moderate yields along fracture/lineament zones.This unit occupy 61.75% in the study area. For groundwater exploration few bore wells were drilled to a depth of 31 to 46 m and some of these wells reported to yield 10.6 to 14.5 bgl (m) in 2002 and 11.6 to 15 bgl (m) in 1998.

Table: 7

Geomorphological map of the study area

Map Symbol	Geomorphic unit	Lithologic unit
I	Inselberg	Grinite (s.l)
P	Pediment Zone	Granite (s.l)
PPM	Pediment with moderate weathering	Granite (s.l), Granite
PPS	Pediment with shallow weathering	Granite (s.l), Granite
RH	Residual hill	Granite
VF	Valley fill sediments	Granite and Granite gneisses

Table: 8
Geological succession of the study area

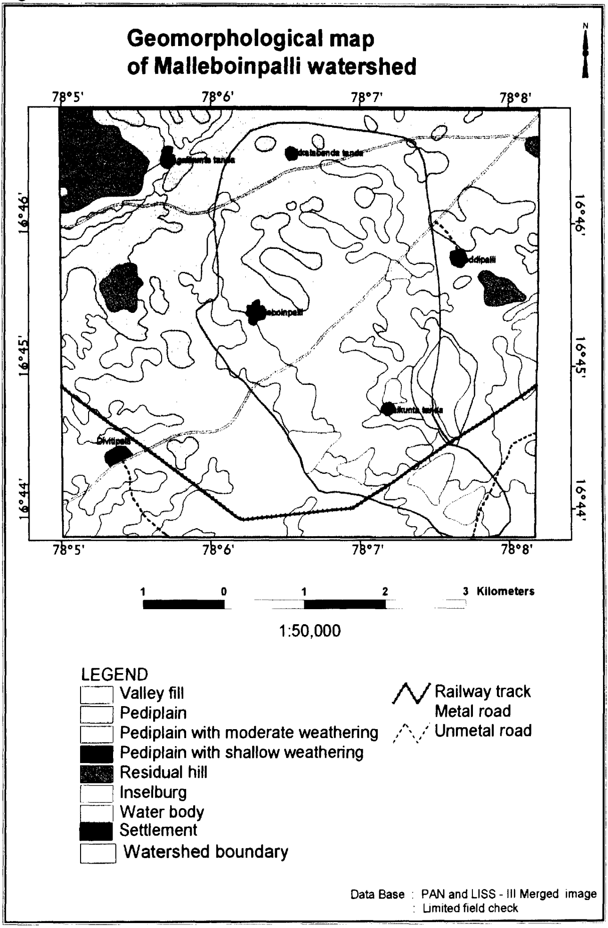
Hydrogeomorphic Unit	Color	Texture	Shape	Size	Pattern	Location/Association
PPM	Pink to Greenish	Smooth	Irregular	Large	Contiguous	Plain agricultural
PPS	Bright Pink	Smooth	Irregular	Large	Contiguous	Plain agricultural land with gentle undulations
P	Brownish yellow	Coarse to medium	Irregular	Varying	Contiguous	Residual hill adjoining the body.
RH	Dark gray	Very coarse	Irregular	Large	Strike ridges contiguous	Hill stand above the surrounding
VF	Red	Fine	Linear	Varying	Contiguous	Surrounded by hills
I	Gray	Medium	Hummock	Small	Contiguous	Isolated hill surrounded

Table : 9
Area statistics :

Geomorphic unit	Area km^2	Area %
Pediplain with moderate weathering	7.588	21.65
Pediplain with shallow weathering	21.645	61.75
Residual Hills	1.560	4.45
Pediplain	3.447	9.85
Vally fills	0.163	0.45
Inselburgs	0.635	1.85
Total -	35.05	100.00

Geomorphology map shown in Fig : 9

Fig. 9


Geomorphological map
of Malleboinpalli watershed
N
78°5'
78°6'
78°7'
78°8'
16°46'
16°45'
16°44'
1 0 1 2 3 Kilometers
1:50,000
LEGEND
Valley fill
Pediplain
Pediplain with moderate weathering
Pediplain with shallow weathering
Residual hill
Inselburg
Water body
Settlement
Watershed boundary
Railway track
Metal road
Unmetal road
Data Base : PAN and LISS - III Merged image
: Limited field check

5.6. Well Location map:

This map showing the wells located in different places and water levels in 1998 and 2002. spatial data and attribute data are integrated in ARC/INFO. And particular well details like type of well, well position etc. are shown in table- 15 and 16.

This map is useful for identification of good groundwater potential in the study area. And also identification of groundwater position in the area.

Well location map is shown in Fig : 10

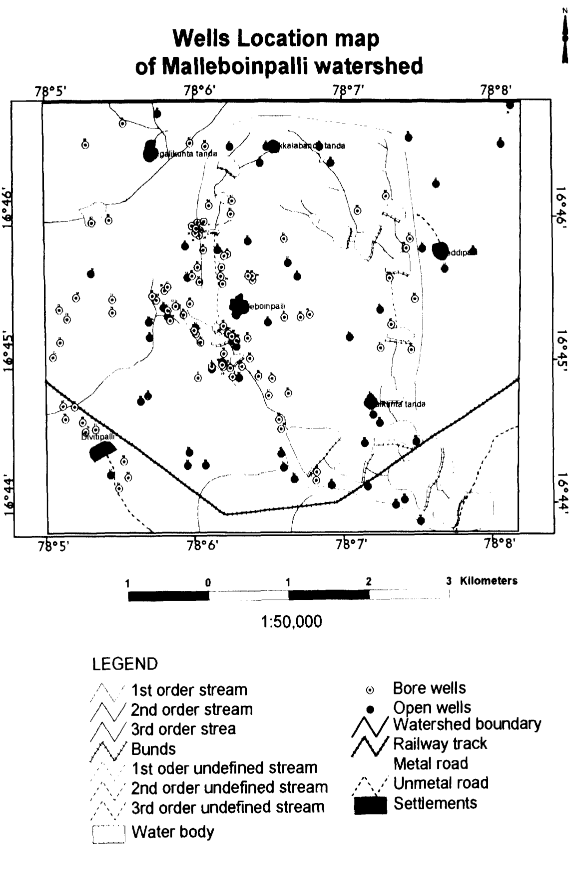
5.7. Lineament map:

Lineaments in the study area are less. Lineament density is less. It indicate in this area runoff potential also less. In the study area lineaments are within the pediment zone may be a potential site for the groundwater development.

Lineament map shown in Fig: 11.

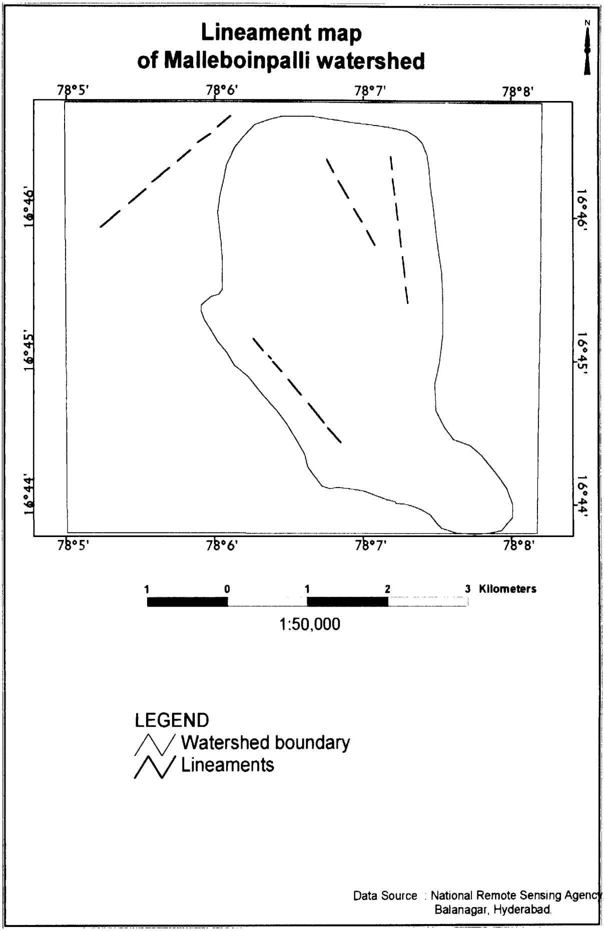
Fig. 10

Wells Location map of Malleboinpalli watershed



Database : Field Data

Fig. 11


Lineament map
of Malleboinpalli watershed
N
78°5'
78°6'
78°7'
78°8'
16°46'
16°45'
16°44'
1 0 1 2 3 Kilometers
1:50,000
LEGEND
Watershed boundary
Lineaments
Data Source : National Remote Sensing Agency,
Balanagar, Hyderabad.

5.8. Groundwater prospect Map, 2002:

Six types of groundwater potential zones are delineated. Those are Excellent, Good, Moderate, Normal to Poor, Poor, Very poor.

a. Excellent:-

In this zone very gentle slope is observed. Slope percentage is 1 to 3 %.In this area land use pattern is Kharif un-irrigated. Near Mangalikunta Thanda valley fill area has excellent groundwater potential. Groundwater conditions in this area are excellent and groundwater is exploited through dug wells and bore wells. 0.159 Km^2 area are with excellent groundwater potential in the Malleboinpalli area.

b. Good:-

Good groundwater potential zones occupy 8.090 Km^2 of area.In this zone very gentle slope and nearly level slope is observed. Slope percentage is 0 to 3%. In this area land use pattern is kharif un-irrigated and double crop. Granites and biotite igneous characterize the area. From groundwater point of view these units are suitable for dug wells and shallow bore/ tube wells because of their good potential with sustained yield. Near Mangali kunta Thanda, near Malleboinpalli, and near Bureddipalli villages contain good groundwater potential zones. In this area are also seen lineaments. This lineaments indicate the good groundwater potential status.

In this zone 37 bore wells are there, two bore wells are dried This bore well having average annual groundwater levels 14.5 bgl(m) to 15.7 bgl(m). In this zone 18 open wells are also there, in these wells only two wells are functioning and remaining open wells are dried. Annual average groundwater levels in this wells are 11.5 bgl(m) to 10.7 bgl(m).

c. Moderate:-

In this zone gentle, moderate, nearly level, very gentle slopes are observed. Slope percentage is below 10%. In this zone land use pattern is mainly kharif un- irrigated. Dolomites and lime stones characterize the area. It consists of unconsolidated alluvial material made up of rock debris and soil thickness of 0-5m with constant recharge from streams differing moderate yields along fracture/lineament zones. 21.016 Km^2 of moderate potential zones in the study area.

In this zone 44 bore wells are there, in this bore wells average annual groundwater levels 10.6 bgl (m) to 14.5 bgl(m). In this zone 27 open wells are there, which were dried at the time of study.

d. Normal to poor:-

In this zone gentle, moderate, steep slope are observed. Slope percentage in this area are 3 to 15%.Land use pattern in this area are scrub forest, land with scrub, kharif un-irrigated. In the study area 3.717 Km^2 of area contain normal to poor groundwater potential zones. Lineaments present in the area indicate some scope for movement of groundwater and hence suitable for groundwater prospecting. Normal to good groundwater potential status occupy large area in Mangalikunta Tanda, Bureddipalli, Mallaboinpalli.

In this zone 8 bore wells are observed, in this bore wells average annual average groundwater levels are 8.5 bgl(m) to 10.5 bgl(m) and 4 open wells are there, which were dried.

e. Poor:-

In this area steep slope are observed. Slope percentage are 15 to 35%.Land use pattern in this area are barren rocks. Residual hill area contain poor, but narrow valleys often contain springs and seepage's suitable for dug wells and bore wells. Poor groundwater prospect identified near Mangalikunta Thanda and near Bureddipalli village. In the Malleboinpalli area 1.459 Km^2 of area contain poor groundwater potential zones.

In this zone 2 bore wells are observed, groundwater levels in this bore wells are <8.5 bgl (m). Open wells are not observed in this zone.

f. Very poor:-

In this area steep slope are observed. Slope percentage are >35%. This area has isolated hills. This unit is acting as a surface facilitating runoff due to slope. That is the reason for very poor groundwater potential.0.598 Km^2 of area contain poor or nil groundwater potential.
In this zone bore wells and open wells are not observed.

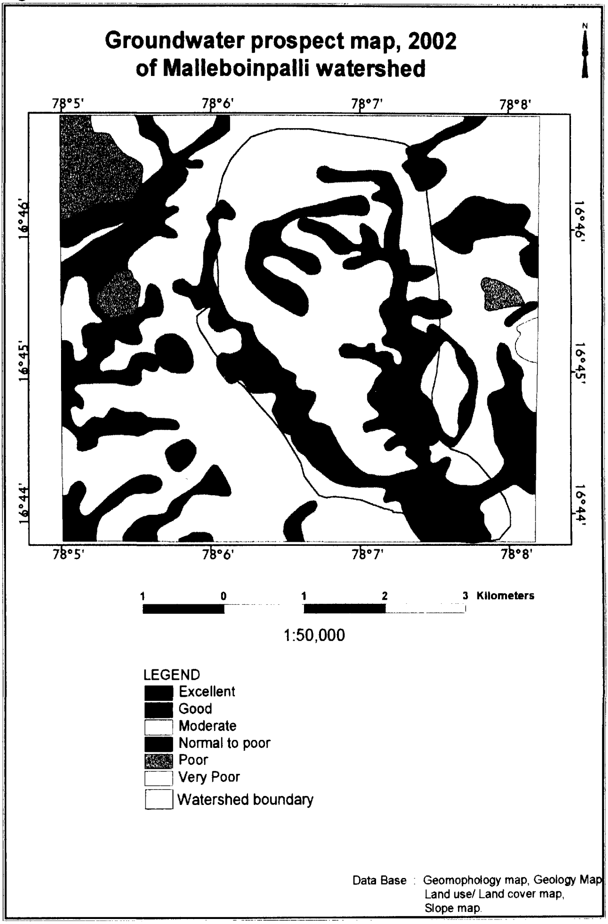
Table : 10

groundwater levels of wells in the Malleboinpalli area in the year 2002;

Groundwater status	Area Km^2	Percentage (%)	No.of bore wells	Groundwater level bgl (m)	No.of open wells	Groundwater level bgl(m)
Excellent	0.159	0.45	--	>15.8	--	--
Good	8.090	23.00	37	14.5 – 15.7	18	11.5 – 10.7
Moderate	21.016	60.00	44	10.6 – 14.5	27	Dried
Normal to poor	3.717	10.75	8	8.5 – 10.5	4	Dried
Poor	1.459	4.10	2	<8.5	--	--
Very poor	0.598	1.70	--	--	--	--
Total:	35.05	100.00	91		49	

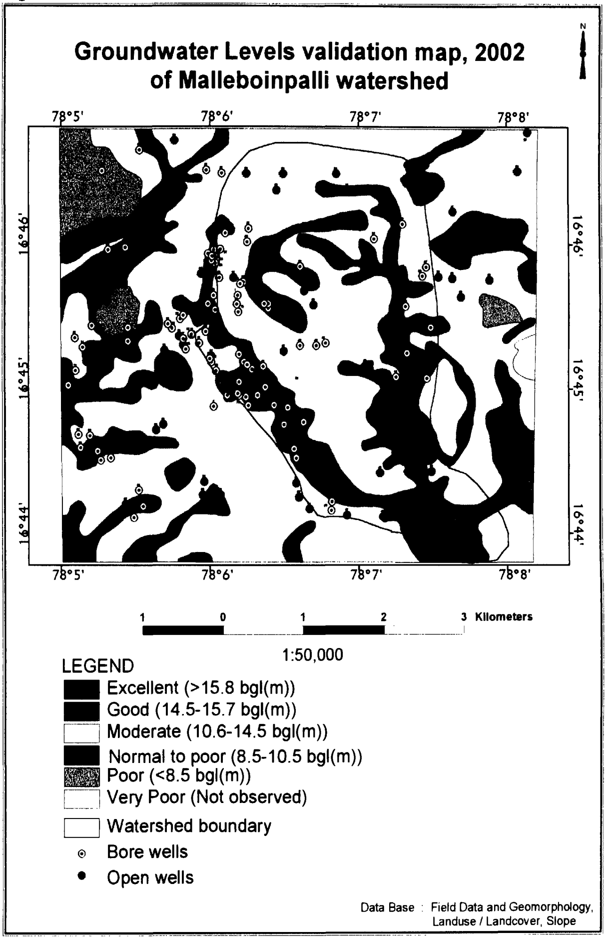
Groundwater prospect zone map is shown in Fig : 12
Groundwater validation map is shown in Fig :13.

Fig. 12



Groundwater prospect map, 2002
of Malleboinpalli watershed
N
78°5'
78°6'
78°7'
78°8'
16°46'
16°45'
16°44'
1 0 1 2 3 Kilometers
1:50,000
LEGEND
Excellent
Good
Moderate
Normal to poor
Poor
Very Poor
Watershed boundary
Data Base : Geomophology map, Geology Map
Land use/ Land cover map,
Slope map

Fig. 13



Groundwater Levels validation map, 2002
of Malleboinpalli watershed
N
78°5'
78°6'
78°7'
78°8'
16°46'
16°45'
16°44'
1 0 1 2 3 Kilometers
1:50,000
LEGEND
Excellent (>15.8 bgl(m))
Good (14.5-15.7 bgl(m))
Moderate (10.6-14.5 bgl(m))
Normal to poor (8.5-10.5 bgl(m))
Poor (<8.5 bgl(m))
Very Poor (Not observed)
Watershed boundary
Bore wells
Open wells
Data Base : Field Data and Geomorphology, Landuse / Landcover, Slope

5.9. Groundwater prospect Map, 1998:

Six types of groundwater potential zones are delineated. Those are Excellent, Good, Moderate, Normal to Poor, Poor, Very poor.

a. Excellent:

In this zone very gentle slope is observed. Slope percentage is 1 to 3 %.In this area land use pattern is Kharif un-irrigated. Near Mangalikunta Thanda valley fill area has excellent groundwater potential. Groundwater conditions in this area are excellent and groundwater is exploited through dug wells and bore wells. Wells are not observed in this area. Excellent groundwater potential in the Malleboinpalli area occupied 0.245 Km^2.

b. Good:

In this zone very gentle slope and nearly level slope is observed. Slope percentage is 0 to 3%. Granites and biotite igneous characterize the area. From groundwater point of view these units are suitable for dug wells and shallow bore/ tube wells because of their good potential with sustained yield. Near Mangali kunta Thanda, near Malleboinpalli, and near Bureddipalli villages contain good groundwater potential zones. In this area are also seen lineaments. This lineaments indicate the good groundwater potential status.

Good groundwater potential zone in the study area occupy 8.592 Km^2. In this zone 37 bore wells are there, two bore wells are dried This bore well having average annual groundwater levels 15 bgl(m) to 16.7 bgl(m). In this zone 18 open wells are there, in these wells only two wells are functioning and remaining open wells are dried. Annual average groundwater levels in this wells are11.6 bgl(m) to 12.5 bgl(m).

c. Moderate:-

In this zone gentle, moderate, nearly level, very gentle slopes are observed. Slope percentage is below 10%. Moderate groundwater potential zone in the study area occupy 20.551 Km^2 .

In this zone 44 bore wells are there, in this bore wells average annual groundwater levels 11.6 bgl (m) to 15 bgl(m). In this zone 27 open wells are there, which were are dried.

d. Normal to poor:-

In this zone gentle, moderate, steep slope are observed. Slope percentage in this area are 3 to 15%.Land use pattern in this area are scrub forest, land with scrub, kharif un-irrigated. Normal to poor groundwater potential zone in the study area occupy 3.754 Km^2

In this zone 8 bore wells are observed, in this bore wells average annual average groundwater levels are 9.5 bgl(m) to 11.6 bgl(m) and 4 open wells are there, which were dried.

e. Poor:-

In this area steep slope are observed. Slope percentage are 15 to 35%.Land use pattern in this area are barren Rocks. Residual hill area contain poor, but narrow valleys often contain springs and seepage's suitable for dug wells and bore wells Poor groundwater potential zone in the study area occupy 1.316 Km^2 Poor groundwater prospect identified near Mangalikunta tanda and near Bureddipalli village.

In this zone 2 bore wells are observed, groundwater levels in this bore wells are <9.5 bgl (m). Open wells are not observed in this zone.

f. Very poor:-

In this area steep slope are observed. Slope percentage are >35%. This area has isolated hills. This unit is acting as a surface facilitating runoff due to slope. A That is the reason for very poor groundwater potential. In this zone bore wells and open wells are not observed.

Table : 11

Groundwater levels of wells in the Malleboinpalli area during the year 1998;

Groundwater status	Area Km^2	Percentage (%)	No.of bore wells	Groundwater level bgl (m)	No.of open wells	Groundwater level bgl(m)
Excellent	0.245	0.70	--	>16.7	--	--
Good	8.592	24.50	37	15 – 16.7	18	11.6 – 12.5
Moderate	20.551	58.60	44	11.6 – 15	27	Dried
Normal to poor	3.754	10.75	8	9.5 – 11.6	4	Dried
Poor	1.316	3.75	2	<9.5	--	--
Very poor	0.580	1.70	--	--	--	--
Total:	35.05	100.00	91			

Groundwater prospect map is shown in Fig : 14.

Groundwater validation map is shown in Fig :15.

Table : 12

Groundwater potential fluctuations in the study area during the year 1998 and 2002 :

Groundwater status	1998	2002
	Area km^2	Area km^2
Excellent	0.245	0.159
Good	8.592	8.090
Moderate	20.551	21.016
Normal to Poor	3.754	3.717
Poor	1.316	1.459
Very poor	0.580	0.598
Total -	35.05	35.05

Fig. 14

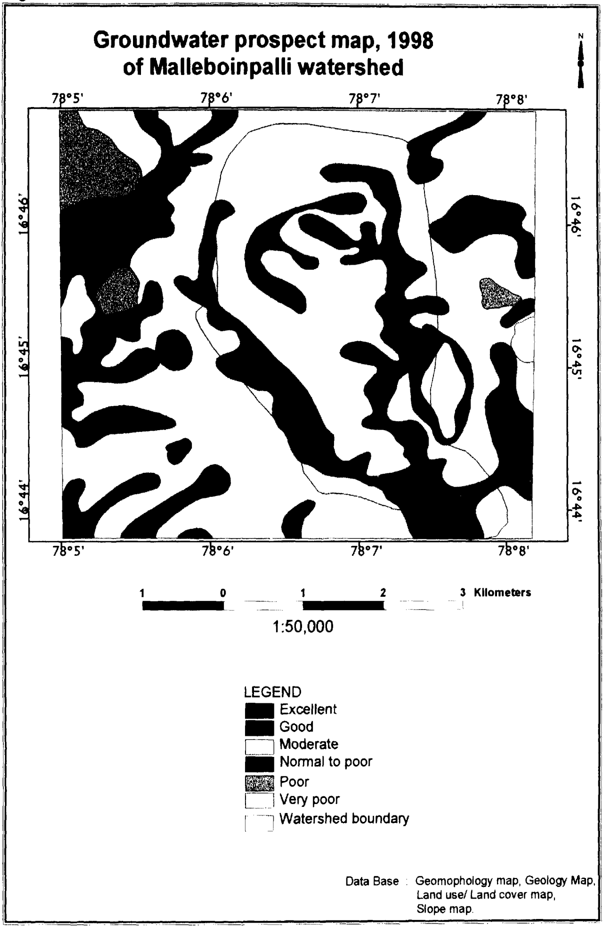
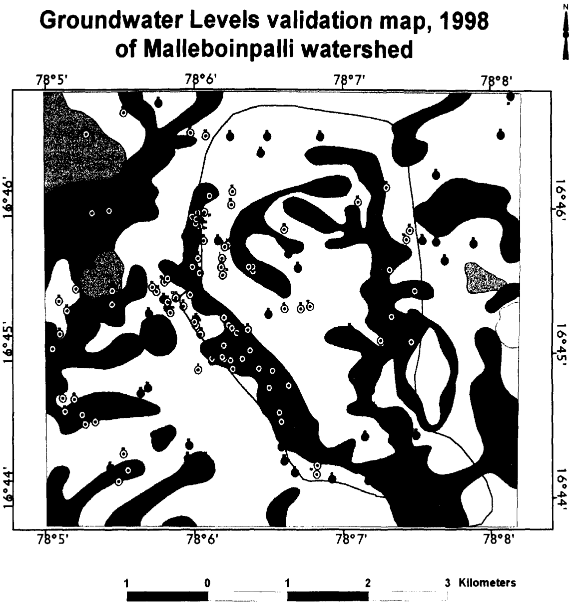

Groundwater prospect map, 1998
of Malleboinpalli watershed
N
78°5'
78°6'
78°7'
78°8'
16°46'
16°45'
16°44'
1 0 1 2 3 Kilometers
1:50,000
LEGEND
Excellent
Good
Moderate
Normal to poor
Poor
Very poor
Watershed boundary
Data Base : Geomophology map, Geology Map,
Land use/ Land cover map,
Slope map.

Fig. 15

Groundwater Levels validation map, 1998 of Malleboinpalli watershed



LEGEND

- Excellent (>16.8 bgl(m))
- Good (15-16.7 blg(m))
- Moderate (11.6-15 bgl(m))
- Normal to poor (9.5-11.6 bgl(m))
- Poor (<9.5 bgl(m))
- Very poor (Not observed)
- Watershed boundary
- Bore wells
- Open wells

Data Base : Field Data and Geomorphology, Landuse / Landcover, Slope

5.10. Geology Map:

Granites cover total study area. Those are occurring as linear ridges, hills, inselbergs and sheet-like exposures.

Granites (s.l) display distinct intrusive relationship with the metamorphics. The granites comprise several textural and compositional variants such as granodiorite, horn blended granite, medium to coarse granied grey granite (mafic poor). However the medium to coarse grained biotite granite and very coarse grained porphyritic granite are widely distributed. The contact relationship between the various types of granites is transitional. These granites are either foliated or non-foliated and compositionally belong to tonalite- granodiorite- adamellite suite.

Granites S.L occupy in the study area are 33.208 Km^2(94.75%).

Granites occupy in the study area are 1.833 Km^2(5.25%).

Geology map is shown in Fig. 16.

Fig. 16

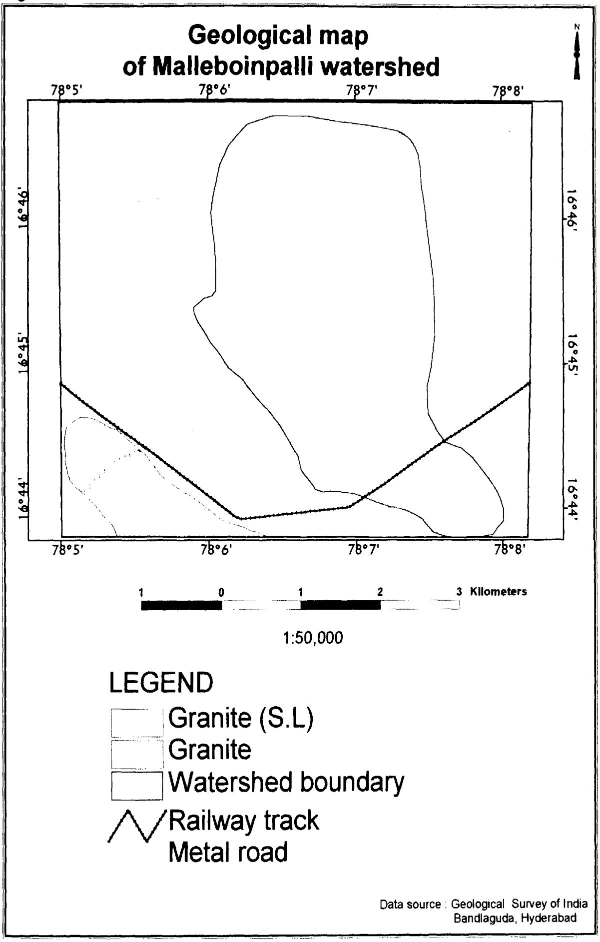

Geological map
of Malleboinpalli watershed
N
78°5'
78°6'
78°7'
78°8'
16°46'
16°45'
16°44'
1
0
1
2
3 Kilometers
1:50,000
LEGEND
Granite (S.L)
Granite
Watershed boundary
Railway track
Metal road
Data source : Geological Survey of India
Bandlaguda, Hyderabad

Table : 13

Water levels variation in bore wells during the years 1998 and 2002 :

Well ids	wl - 2002 bgl (m)	wl - 1998 bgl (m)
1	11.5	14.7
2	12.7	13.5
3	11.8	14.8
4	15.2	16.2
5	15.6	16.1
6	12.6	13.5
7	11.7	14.3
8	15.3	16.2
9	13.7	13.6
10	14.6	14.7
11	13.4	13.7
12	14.2	15.2
13	13.2	14.1
14	0	0
15	0	0
16	14.9	16.2
17	11.5	12.5
18	14.7	15.6
19	12.4	13.2
20	13.6	14.3
21	10.8	11.8
22	8.8	9.5
23	14.9	15.7
24	14.2	15.9
25	0	0
26	14.3	14.67
27	15.6	16.7
28	14.1	15.4
29	15.2	16.3
30	9.2	10.7
31	9	10.4
32	8.5	9.7
33	0	0
34	14.2	15.3
35	13.9	14.2
36	14.7	15.9
37	15.1	16.7
38	9.2	10.7
39	9.6	10.4

Well ids	wl - 2002 bgl (m)	wl - 1998 bgl (m)
41	10.6	11.8
42	13.5	14.3
43	13.6	14.2
44	11	11.6
45	9.5	10.4
46	10.82	11.5
47	9.7	10.6
48	9.6	10.4
49	9.3	10.7
50	11.53	12.6
51	15.4	16.8
52	9.8	10.4
53	11.72	12.6
54	11.5	12.7
55	10.5	11.7
56	11.6	12.4
57	13.2	13.8
58	12.5	13.2
59	12.4	13.6
60	10.8	11.3
61	11.5	12.4
62	10.5	11.6
63	12.3	13.5
64	13.2	14.6
65	13.2	13.9
66	14.2	15.8
67	11.3	12.80
68	12.2	13.7
69	12.7	13.8
70	12.3	13.6
71	11.6	12.8
72	12.2	13.7
73	12.7	14.2
74	13.4	14.2
75	13.7	15.3
76	13.2	14.8
77	10.8	11.9
78	10.1	11.5
79	13.6	14.6
80	12.5	13.6
81	11.7	14.8

Well ids	wl - 2002 bgl (m)	wl - 1998 bgl (m)
83	10.7	11.2
84	12.4	13.3
85	12.3	13.8
86	12.4	13.7
87	13.6	14.4
88	14.2	15.7
89	13.5	14.1
90	14.2	16.2
91	9.2	12.6

Note: '0' indicate well dried.

Table: 14

Water levels variation in open wells during the years 1998 and 2002:

Well Id	WL bgl (m) – 2002	WL bgl (m) - 1998
5	11.4	12.5
14	10.9	12.2

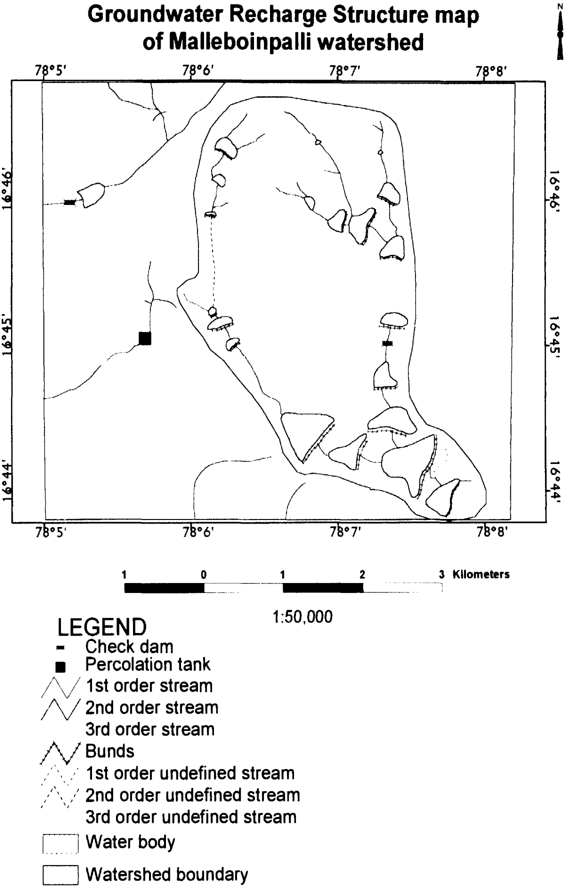
5.11. Groundwater recharges structure Map:

This map show the water recharge structures. Mainly in hilly area runoff percentage is very high. In this area water flow regulation is necessary. Check dams are suitable in this area. Overflow water is flows near to tanks. And percolation tanks are useful for groundwater recharge.

Recharge structure map is shown in Fig: 17.

Fig. 17

Groundwater Recharge Structure map of Malleboinpalli watershed



Data Base : Slope map, Drainage map

Well Id	Owner Name	Survey Number	Latitude	Longitud	Type of Owneshi	Construction year	Type of well	Cost of Initial Investment	Maintenance cost	Depth of well	No.of Years in Productive use	Water quality	Use	Water used for Irrigation	Mode of drawn	Pumping Datum	Use for Pumping	wl - 2002 bgl(m)	wl - 1998 bgl (m)
1	Rami Reddy	47	16.7498	78.0023	Private	1995-96	C	5800	1000	150	8	Good	Irrigation	8-50 acrs-cents	Current Pump	5 H P	5hr/day	11.5	15.53
2	Rami Reddy	73	16.7493	78.1025	Private	1995-96	C	5800	0	150	8	Good	Irrigation	3-10 acrs-cents	Current Pump	5 H P	2hr/day	9.3	15.67
3	Dasarada Reddy	70/A/E	16.7493	78.1048	Private	1995-96	C	5800	0	150	8	Good	Irrigation	3-10 acrs-cents	Current Pump	5 H.P	2hr/day	8.2	15.13
4	V. Malla Reddy	69/A/1	16.7491	78.1033	Private	1996-97	C	5800	500	150	7	Good	Irrigation	3-00 acrs-cents	Current Pump	5 H P	2hr/day	9.5	15.87
5	V Hanumantha Reddy	70/C	16.7481	78.1036	Private	1996-97	C	5800	0	150	7	Good	Irrigation	3-00 acrs-cents	Current Pump	5 H P	2hr/day	9.2	14.98
6	V Venkat Reddy	45/D	16.7493	78.1025	Private	1995-96	C	6000	300	160	8	Good	Irrigation	5-00 acrs-cents	Current Pump	5 H P	3hr/day	9.4	15.78
7	V. Venkat Reddy	72/1/A	16.7493	78.1025	Private	1995-96	C	6200	200	170	8	Good	Irrigation	6-00 acrs-cents	Current Pump	5 H.P	3.3hr/day	9.2	15.84
8	V. Chandra Reddy	76	16.7493	78.1010	Private	1995-96	C	6200	0	170	8	Good	Irrigation	7-00 acrs-cents	Current Pump	5 H P	4hr/day	9.3	15.24
9	V. Mannem Reddy	78	16.7480	78.0993	Private	1994-95	C	6200	0	170	9	Good	Irrigation	10-00 acrs-cents	Current Pump	5 H P	5hr/day	9.5	15.83
10	G. Krishna Reddy	73/A	16.7495	78.1023	Private	1995-96	C	6000	0	160	8	Good	Irrigation	3-50 acrs-cents	Current Pump	5 H P	2hr/day	8.4	15.12
11	S. Lakshmamma	145	16.7563	78.0966	Private	1997-98	C	6000	0	160	6	Good	Irrigation	3-00 acrs-cents	Current Pump	5 H P	2hr/day	8.7	15.23
12	S. Jangaiah	145	16.7563	78.0965	Community	1996-96	C	6200	0	170	8	Good	Irrigation	6-00 acrs-cents	Current Pump	5 H P	3hr/day	9.1	16.12
13	S Narayana	145	16.7553	78.0975	Private	1996-96	C	5800	0	150	8	Good	Irrigation	3-00 acrs-cents	Current Pump	5 H P	2hr/day	9.3	15.13
14	S. Kasappa	145	16.7566	78.0983	Private	1996-96	C	5800	0	150	0	0	0	0	0	0	0	0	0
15	Alle Balaiah	96/D	16.7570	78.0941	Private	1995-96	C	6000	300	160	0	0	0	0	0	0	0	0	0
16	V Hanumantha Reddy	96/C	16.7546	78.0958	Private	1997-98	C	6000	0	160	6	Good	Irrigation	6-00 acrs-cents	Current Pump	5 H P	3.3hr/day	8.7	16.23
17	V Dasarada Reddy	96/A	16.7558	78.0955	Private	1996-97	C	6000	0	160	7	Good	Irrigation	6-00 acrs-cents	Current Pump	5 H P	3hr/day	8.9	14.24
18	K. Badhru Naiak	106/D	16.7573	78.0841	Private	1997-98	C	6200	500	170	6	Good	Irrigation	2-00 acrs-cents	Current Pump	5 H P	1.3hr/day	8.5	14.34
19	K. Badhru Naiak	106/D	16.7575	78.0936	Private	1997-98	C	5800	0	150	6	Good	Irrigation	3-00 acrs-cents	Current Pump	5 H P	2hr/day	9.4	14.36
20	Common Bore	142	16.7581	78.0951	Community	1997-98	C	6400	0	180	6	Good	Irrigation	5-00 acrs-cents	Current Pump	5 H P	3hr/day	8.5	15.24
21	Common Bore	142	16.7585	78.0955	Community	1997-98	C	6200	0	170	6	Good	Irrigation	3-00 acrs-cents	Current Pump	5 H P	2hr/day	9.7	15.67
22	K. Somla	22/A/2	16.7641	78.1101	Private	1996-97	C	6000	0	160	7	Good	Irrigation	3-00 acrs-cents	Current Pump	5 H P	2hr/day	8.8	15.25
23	K. Takya	22/B/B	16.7651	78.0996	Private	1997-98	C	6000	200	160	6	Good	Irrigation	4-00 acrs-cents	Current Pump	5 H P	3hr/day	9.5	16.14
24	K. Takya	22/B/B	16.7645	78.0995	Private	1997-98	C	6000	0	160	6	Good	Irrigation	4-00 acrs-cents	Current Pump	5 H P	3hr/day	9.3	16.35
25	K. Sakrow	22/B/B	16.7660	78.0993	Private	0	C	6000	0	160	0	0	0	0	0	0	0	0	0
26	Bandi Venkataiah	19/F	16.7648	78.0990	Private	1997-98	C	6000	0	160	6	Good	Irrigation	4-00 acrs-cents	Current Pump	5 H P	3hr/day	8.9	14.67
27	Bandi Venkataiah	19/E	16.7656	78.0986	Private	1997-98	C	6000	0	160	6	Good	Irrigation	4-00 acrs-cents	Current Pump	5 H P	3hr/day	9.7	15.68
28	Bandi Venkataiah	19/A	16.7653	78.0991	Private	1997-98	C	6400	500	180	6	Good	Irrigation	4-00 acrs-cents	Current Pump	5 H P	3hr/day	9.3	15.89
29	Musti Venkataiah	16/A	16.7628	78.1000	Private	1997-98	C	6400	500	180	6	Good	Irrigation	8-50 acrs-cents	Current Pump	5 H P	5hr/day	9.5	16.45
30	Musti Gopal	29/A/C	16.0775	78.0993	Private	1996-97	C	6200	0	170	7	Good	Irrigation	4-50 acrs-cents	Current Pump	5 H P	3hr/day	9.2	16.27
31	Burla Venkataiah	146/1	16.7531	78.0990	Private	1996-97	C	6200	0	170	7	Good	Irrigation	4-50 acrs-cents	Current Pump	5 H P	3hr/day	9	15.34
32	Burla Achamma	146/2	16.7535	78.9880	Private	1997-98	C	6200	0	170	6	Good	Irrigation	4-50 acrs-cents	Current Pump	5 H P	3hr/day	8.5	14.87
33	V Tirupathi Reddy	147	16.7521	78.0996	Private	1997-98	C	6200	0	170	0	0	0	0	0	0	0		0
34	K. Tulsiya	31/D/1	16.7623	78.1030	Private	1997-98	C	6400	300	180	6	Good	Irrigation	2-20 acrs-cents	Current Pump	5 H P	1.3hr/day	8.5	14.43
35	K. Cheenya	31/D/2	16.7621	78.1026	Private	1997-98	C	6200	0	170	6	Good	Irrigation	2-50 acrs-cents	Current Pump	5 H P	1.3hr/day	8.4	14.34
36	Andhya Naik	7	16.7598	78.0986	Private	1995-96	C	6200	0	170	8	Good	Irrigation	2-20 acrs-cents	Current Pump	5 H P	1.3hr/day	8.7	15.13
37	K. Bheekya	134	16.7661	78.1001	Private	1997-98	C	6200	0	170	6	Good	Irrigation	3-50 acrs-cents	Current Pump	5 H P	2hr/day	10.1	16.24
38	P. Lakshmaiah	0	16.7593	78.1061	Private	1994-95	C	6200	150	170	9	Good	Irrigation	5-10 acrs-cents	Current Pump	5 H P	3hr/day	9.2	15.65
39	C. Pentaiah	0	16.7598	78.1061	Private	1994-95	C	6200	0	170	9	Good	Irrigation	4-00 acrs-cents	Current Pump	5 H P	3hr/day	9.6	15.67
40	Kavali Krishnaiah	0	16.7598	78.1056	Private	1994-95	C	6200	0	170	9	Good	Irrigation	2-10 acrs-cents	Current Pump	5 H P	1.3hr/day	8.4	15.23
41	Chakali Ramulu	0	16.7550	78.1101	Private	1994-95	C	6000	100	160	9	Good	Irrigation	3-00 acrs-cents	Current Pump	5 H P	2hr/day	9.5	16.34
42	Kavali Balaiah	0	16.7550	78.1121	Private	1994-95	C	6000	0	160	9	Good	Irrigation	3-00 acrs-cents	Current Pump	5 H P	2hr/day	9.7	16.43
43	Kavali Balaiah	0	16.0886	78.1133	Private	1994-95	C	6000	0	160	9	Good	Irrigation	2-10 acrs-cents	Current Pump	5 H P	1.3hr/day	8.3	16.43
44	Beside Anjaneya Temple	0	16.7531	78.1031	Governmen	0	C	0	0	0	0	Good	Domestic	0	Current Pump	5 H.P	4hr/day	11	19.54
45	Starting of the Village	0	16.7540	78.1025	Governmen	0	C	0	0	0	0	Good	Domestic	0	Current Pump	5 H P	2hr/day	9.5	19.54
46	Starting of the Village	0			Governmen	0	C	0	0	0	0	Good	Domestic	0	Current Pump	5 H P	3hr/day	10.82	18.54
47	In Harizanawada	0	16.7508	78.1025	Governmen	0	C	0	0	0	0	Good	Domestic	0	Current Pump	5 H P	2hr/day	9.7	19.52
48	Vurabavi	0	16.7528	78.1036	Governmen	0	C	0	0	0	0	Good	Domestic	0	Current Pump	5 H.P	2hr/day	9.6	18.59
49	Satya Sai Bore well	0	16.7523	78.1041	Governmen	0	C	0	0	0	0	Good	Domestic	0	Current Pump	5 H P	2hr/day	9.3	18.52
50	Entrance of the village	0	16.7526	78.1055	Governmen	0	C	0	0	0	0	Good	Domestic	0	Current Pump	5 H.P	4hr/day	11.53	19.34
51	Near Temple	0	16.7528	78.1035	Governmen	0	C	0	0	0	0	Good	Domestic	0	Current Pump	5 H P	2hr/day	9.7	18.27
52	Tanda Bore	0	16.7591	78.0995	Governmen	0	C	0	0	0	0	Good	Domestic	0	Current Pump	5 H.P	2hr/day	9.8	17.89
53	Naikkala Banda Tanda	0			Governmen	0	C	0	0	0	0	Good	Domestic	0	Current Pump	5 H P	4hr/day	11.72	19.58

Open well inventory of Malleboinpalli area

Well Id	Owner Name	Survey number	Latitude	longitud	Type of ownership	Construction year	Type of well	Cost of initial investment	Maintenance cost	Depth of well	Position of the well	No. of years in productive use	Water quality	use	Water used for irrigation	Mode of drawl	Pumping device	Used for pumping	wl-2002 bgl(m)	wl-1998 bgl(m)
1	Rami Reddy	47	16 7498	78 1023	Private	1994-95	A	1000	0	80 ft	B	0	0	0	0	0	0	0	0	0
2	Dasaradha Reddy	70	16 7493	78 1048	Private	1994-95	A	1000	0	80 ft	B	0	0	0	0	0	0	0	0	0
3	V.Venkata Reddy	72/1/A	16 7493	78 1025	Private	1993-94	A	800	0	60 ft	B	0	0	0	0	0	0	0	0	0
4	V.Chandra Reddy	76	16 7490	78 1010	Private	1994-95	A	1000	200	60 ft	B	0	0	0	0	0	0	0	0	0
5	V. Mannem Reddy	83	16 7480	78 0993	Private	1993-94	A	800	0	95 ft	B1	9	GOOD	irrigation	4-00acrs-cents	Electric pump	5 H P	3 hr/day	11 4	12.5
6	V. Tirupati Reddy	147	16 7521	78 0996	Private	1993-94	A	800	0	90 ft	B	0	0	0	0	0	0	0	0	0
7	S Lakshmamma	145	16 7563	78 0966	Private	1993-94	A	800	0	90 ft	B	0	0	0	0	0	0	0	0	0
8	Group Well	78	16 7495	78 1025	community	1993-94	A	800	0	90 ft	B	0	0	0	0	0	0	0	0	0
9	S Narayana	145	16.7553	78 0975	private	1993-94	A	800	100	90 ft	B	0	0	0	0	0	0	0	0	0
10	S. Kasappa	145	16 7566	78 0983	Private	1994-95	A	1000	0	80 ft	B	0	0	0	0	0	0	0	0	0
11	Alle Balaiah	96/E	16 7561	78 0950	Private	1994-95	A	1000	0	80 ft	B	0	0	0	0	0	0	0	0	0
12	Dasaradha Reddy	96/A	16 7551	78 0955	Private	1993-94	A	800	0	80 ft	B	0	0	0	0	0	0	0	0	0
13	Burla Venkataiah	146	16 7538	78 0990	Private	1995-96	A	1100	100	80 ft	B	0	0	0	0	0	0	0	0	0
14	S. Jangaiah	145	16.7596	78 0980	Private	1993-94	A	800	0	100 ft	B1	9	GOOD	irrigation	4-00 acrs-cents	Electric pump	5 H P	3 hr/day	10 9	12 2
15	B Venkataiah	19	16 7656	78 0986	Private	1994-95	A	1000	0	90 ft	B	0	0	0	0	0	0	0	0	0
16	Musti Gopal	29	16.7601	78 0860	Private	1994-95	A	1000	0	90 ft	B	0	0	0	0	0	0	0	0	0
17	Andhya Naik	7	16 7598	78 0986	Private	1993-94	A	800	0	80 ft	B	0	0	0	0	0	0	0	0	0
18	Near Anjaneya Temple		16 7531	78 1030	Government	1993-94	A	0	0	80 ft	B	0	0	0	0	0	0	0	0	0
19	F.C Open well		16 7523	78 1036	Private	1993-94	A	0	0	80 ft	B	0	0	0	0	0	0	0	0	0
20	S C Open well		16 7516	78 1041	Private	1993-94	A	0	0	80 ft	B	0	0	0	0	0	0	0	0	0
21	Near temple(Vura Bavi)		16 0695	78 1035	Private	1993-94	A	0	0	80 ft	B	0	0	0	0	0	0	0	0	0

In the present study area groundwater potential zones(2002) declined compared to 1998. Excellent, good, normal to poor, groundwater potential zones are decreased, and moderate, poor, very poor zones are increased which indicate future groundwater depletion.

There are several reasons for decrease in to the groundwater levels. They are –annual average rainfall decrease along with over exploitation of groundwater by increased digging of wells. Present condition leads to groundwater scarcity. In the area bore wells are functioning in good condition in rainy season, but in summer some bore wells are not functioning and in some bore wells pumping hours are decreasing. In Malleboinpalli area electric motors are used for pumping. Electric motors having 5 H.P datum. Before last 5 years they use same motors but pumping time is increasing in present days. Water quality not much changed, it is good for irrigation and domestic purposes. In 1998 water used for irrigated area are more compared with 2002 irrigated area. Reason for decreasing of irrigated area are groundwater levels are decreased and rainfall also decreased.

In the study area open wells are completely dried, only two wells are functioning in good condition. In the study area groundwater potential is moderate. This potential is not enough for domestic and agricultural purpose. This area people are mainly depend on groundwater. Groundwater recharge is necessary for future.

Artificial recharge is necessary for increasing of groundwater levels. Some recommendation are given to improve the groundwater levels in the Malleboinpalli area. Those are Percolation Tank and Check Dam. These structures are locate the high runoff area like surrounding of the hilly area. This structures locate in that place, these structures control the runoff and store the rainwater, overflow water if passed to near water bodies.

There are some important steps necessary for groundwater recharge-

- Collection of water in crop lands to increase infiltration.
- Collection and harvesting of excess rainfall.
- Efficient storage of harvested water.
- Water application (lifting and conveyance).
- Optimal utilization of applied water for maximum benefit.

Water Management at Field scale:

There are several practices which could be applied at field level for proper management of water. Those are- Bunding, Land configuration, agronomic measures like tillage,weeding sowing etc. are carried out along the contours in the field.

Water Management at watershed scale :

Water management at watershed scale generally requires involvement of communities for creating an additional resource of water, managing it, and harnessing the benefits of this resource for various purposes. The activities in this category range from management of waterways between fields to storing of excess water above or below ground. Some of those are-

Waterways, farm ponds, Check-dams and gully plugging, Percolation tanks.

Suitable site for digging of wells:

Pediment zone is suitable for groundwater prospecting. In Valley fill area excellent groundwater potential is identified, it is suitable for digging of bore wells and wells. Poor groundwater potential in Residual hills, but narrow valleys often springs, suitable for dugwells. Pediplain with moderate weathering area is suitable for digging of well.

CHAPTER – 6

CONCLUSION

The present study was carried out in Malleboinpalli area in Mahaboob Nagar District. In this area groundwater is main source for irrigation and domestic purpose. In this area groundwater potential status is moderate. It is not enough for future needs. Groundwater levels are drastically decreasing for the last five years. In the area bore wells are functioning in good condition in rainy season, but in summer some bore wells are not functioning and in some bore wells pumping hours are decreasing. In Malleboinpalli area electric motors are using for pumping. Electric motors having 5 H.P datum. Before last 5 years they use same motors but pumping time is increasing in present days. Water quality not much changed, it is good for irrigation and domestic purposes. This situation is going to create difficulties in future. In view of this groundwater recharge is necessary for development of groundwater potential. They are several water conservation structures are there for groundwater recharge. Two types of groundwater recharges structures are recommended in this area. Those are percolation tanks and check dams, as suitable for this area.

The analysis of Remote Sensing data over Malleboinpalli area in Mahaboob Nagar District supported by limited field check and ancillary information enabled delineation of hydrogeomorphological units and assessment of their groundwater potential. In study area observe that the valley fill, pediplain with moderate weathering, pediplain with shallow weathering are classified as excellent, good, moderate groundwater prospect landforms that constitute the investigated area. The Residual hill and inselburgs considered as poor, very poor groundwater prospective zone, because of its massive rock nature. However, adequate recharge source of groundwater can be expected surrounding the RH, as its acts as surface run-off zone. Lineaments parallel to the drainage network areas can give better yields than the other areas. The lineaments can also be utilized to augment the groundwater resources. The area has gentle sloping, which is responsible for infiltration and groundwater recharge.

Pediment zone is suitable for groundwater prospecting. In Valley fill area excellent groundwater potential is identified, it is suitable for digging of bore wells and wells. Poor groundwater potential in Residual hills, but narrow valleys often springs, suitable for dugwells. Pediplain with moderate weathering area is suitable for digging of well.

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APPENDIX

Format for drinking water and sanitation status survey:

Format No.1

Phaliya(Hamlet): Revenue Village:

Gram Panchayat: Block :

Date of Survey: Plot No.:

1. Name of the family head:

2. Respondent ----------------

A. Family Head B. House wife C. Other family members D. Others

3. No. of persons in the family :

Male----- , Female --------, Children below 5 years ----- ,Total -----

4. Source of water:

	Drinking:	Bathing:	Irrigation:	
Own	A. Dugwell	B. Handpump	C. Pond/Tank	D. Tap
Public	E. Dugwell	F. Handpump	G. Pond/Tank	H. Tap
Neighbor's	I. Dugwell	J. Handpump	K. Pond/Tank	L. Others

5. Sanitation facility distance from drinking water source:

6. Whether the drinking water source is satisfactory: -------- yes/no.

7. If no, specify reasons : -----------

A. Poor quality B. Insufficient quantity d. Distance source D. others

8. Type of sanitation facility:

A. Twin leach pit B. Septic Tank C. ESP D. Others

9. Disposal of Waste :

A. Drainage System B. Open canal/ stream C. House Premises
D. Waste material pit E. Others.

10. Disposal Site Distance from drinking water:

Format No.2

Date of Survey: Block: Sheet No.

Phylia(Hamlet): Village: GP :

Survey No. with subdivision of any					
Water extraction structure number					
Ownership type					
Construction year					
Perennial-ity					
Dimension (mm)					
DTWT bgl(m)					
DTWB bGL(m)					
Type of water bearing formation					
Portion of well lined					
Length of lining (m)					
Yearly water table fluctuat-ion					
Water quality					
Use					
No. of people using the same					
Mode of drawn					
Pumping datum					

Draw down on pumping (m)					
Recuperat-ion time (mnt)					
Pumping frequency					
Mode of distribut-ion					
Area irrigated (acres)					
Distance to source of pollution					
Effect of pumping on nearest same					
Maintenan-ce status					
Level of exploitat-ion					
Remarks include reasons to be taken for up keep of the water					

Key:

1. The survey Number and the sub-division number of the plot as given in the Map.

2. The serial number given to each water extraction structure is a plot as noted in the Map.

3. A. Private B. Government C. Community D. Temple, Masque etc.

4. If the year of construction is not exactly known write x for well less than five years and y for wells greater than five years.

5. P-perennial S- seasonal I- induced.

6. Write length and breadth for square well/pond or diameter.

7. Depth of the bottom of the well from the ground level.

8. Depth to the bottom of the well from the ground level.

9. A. sand B. Clay c. Laterite D. Weathered rock
   E. Fractured rock F. Massive rock

10. A. Top B. Middle C. Bottom D. Complete

11. Measure the extent of the lining (protected side wall of well) in meters.

12. Infer the highest water level attained during summer and calculate the difference.

13. A. Good B. Unusable C. Hard D. Saline E. Turbid

14. A. Drinking B. Bathing C. Irrigation
    D. Industrial E. Unused.

15. Write the total number of people using the source.

16. A. Bucket & Rope B. Bullock C. Electric pump D. Diesel pump
    E. Wind Pump F. Solar pump G. others

17. Write the total duration of pumping in minutes per day.

18. Difference after and before pumping.

19. Write the difference between water level after pumping to attain the original water level before pumping .

20. Infer the number of pumping operations carried out per day.

21. A. Pipe line B. Cemented canal C. Earthen canal

22. Infer the total area irrigated using the single source.

23. Distance of source (well / pond / stream) etc. from the latrine, garbage dump, waste water, drainage, bio-gas, installation etc.

24. A. No effect B. Decreasing water level C. Increasing water level

25. A. Silted B. Caved C. None D. Well Main land.

26. A. Over exploited B. Optimally exploited C. Under exploited.

Investment in water wells and use of ground water

Format No. 3 :

Issues in Ground water and well management	Type of well			
Year				
Cost of initial investment(a)				
Other associated investment costs (a+b)				
Initial depth of the well (Ft)				
Current depth of the well (Ft)				
List years when well depth was increased				
Distance from check dam-water recharge				
Total area irrigated paddy/other last 3 years including water given to others				
Water Table (depth in Ft) 1999-00(use of 3 same months from each season - K R S)	Jan May Oct			
Water Table (depth in Ft) 2000-01 year	Jan May Oct			
Water Table (Depth in Ft) 2001-02 year	Jan May Oct			
Do you think water level has decreased (-1) increased (1) or unchanged (0) over tome compared for the same months or seasons ? State reasons for change.				
No. of years in productive use				
Has this well ever dried up in last 3 years ? If yes and for How many months ?				

Perceptions about climatic changes:

Format No. 4 :

A. Is there any changes in rainfall pattern compared to 1996-97 Y/N ?

Characteristics	Description	Main reasons
1. Quantum of rain fall	Increase /decrease /No change	
2. Distribution of rainfall	Highly erratic/No change / better	
3. Number of rainy days	Increase /decrease / No change	
4. Out lier events	Increase /decrease / No change	
5. Arrival events	Early /late /no change	
6. Availability of water from water sources	Increase /decrease / No change	
7.Temperature (winter)	Increase /decrease / No change	
8.emperature (summer)	Increase /decrease / No change	

B. Is there any change in irrigated area operated by you compared to 5 years Y/ N ?

If Yes, answer the following questions.

Crops	Irrigated area in acres			Reasons for increase / decrease of irrigated area
	1996-97	2001-02	status	

C. Do you or your family member try to dig wells or bore wells ? Y/ N

If yes, answer the following questions.

Type	Number of attempts	Depth(Ft) of each attempt	Successful attempts	Presently in use	Total amounts (Rs) spent including failed attempts
1. Open dug well					
2. Bore wells					
3. In well bores					
4. Deepening well					

Water related Details

Format No. 5:

Name of the Revenue village	I	II	III	IV	Total	%
No of Wells						
Dug wells-perennial						
Dug wells-seasonal						
Dug wells-pumping						
Tubewells-perennial						
Tubewells-seasonal						
Tubewells-pumping						
Dug-cum-bore-seasonal						
Dug-cum-bore-perennial						
Stepwell-seasonal						
Stepwell-perennial						
Stepwell-pumping						
Ponds—seasonal						
Ponds- Perennial						
Ponds- Pumping						
Reservoir-Seasonal						
Reservoir-Perennial						
Length of perennial stream						
Length of seasonal stream						
Length of irrigation canal						
Dug well requiring maintenance.						
Tube well requiring maintenance						
Steep well requiring maintenance						
Ponds requiring maintenance						
Reservoir Requiring maintenance						
Length of stream for maintenance.						
Length if canal for maintenance						
No. of over Exploited wells/ponds						
Optimally exploited wells/ponds						
Under exploited wells/ponds						

Format No. 6

Type of environmental problems and the plot numbers.

Name of the Revenue village :

Environmental problems				
Drainage related				
Erosion				
Pollution				
Sanitary				
Seasonal flooding				
Agricultural				