SPATIAL ANALYSIS OF GROUNDWATER STUDIES IN TIRUPPUR DISTRICT USING GIS

PROJECT REPORT

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BONAFIDE CERTIFICATE

This is to certifify that this project report **"SPATIAL ANALYSIS OF GROUNDWATER STUDIES IN TIRUPPUR DISTRICT USING GIS"** is the bonafide work of .... who carried out the project work under my supervision.

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SYNOPSIS

The Avinashi - Athikadavu water scheme is a proposed one with a view to provide water supply to Avinashi, Tiruppur, Perundurai and Kanuvakarai. Water from Bhavani River is diverted through a proposed canal which passes through the above said cities filling the tanks on either side of it. Even though this scheme provides water supply to Tiruppur, there will be water deficiency as literature tells that the water table is very low.

Hence it becomes mandatory to meet out the demands unmet by this scheme. So we have taken up the task of identifying potentially rechargeable zones and the suitable artificial recharge structures to meet the water demand during emergency times.

The land use, soil and geological maps of Tiruppur are collected and they are digitized using Map Info Professional 6.0. Then they are exported to Arc GIS 3.2 and the zones are classified as good, moderate and poor rechargeable zones. With the help of this information the artificial recharge structures are proposed.

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INTRODUCTION

1. INTRODUCTION

1.1 GENERAL

Water is the elixir of life, a precious gift of nature to mankind and millions of other species living on the earth. It is fast becoming a scarce commodity in most part of the world. Water resources comprising of surface water (river and lakes), groundwater and marine and coastal waters, support all living things including human beings. Though water is available in the universe in huge quantity in the order of 1400 x 10^6 km^3, only 3% of the water in the universe is fresh water. Among the fresh water, only about 5% of them or 0.15% of the total world water is readily available for beneficial use. The total water resource available in India is 1850 km^3, which is roughly 4% of the world's fresh water resources. Tamil Nadu accounts for 4 percent of the land area and 6% of the population, but only 3% of the water resources of the country. Most of Tamil Nadu is located in the rain shadow region of the Western Ghats and hence receives limited rainfall from the south-west monsoon.

The state gets relatively more rainfall during north east monsoon, especially, in the coastal regions. The normal rainfall in southwest and north east monsoon is around 322mm and 470mm respectively which are lower than the national normal rainfall of 1250mm.similarly, the per capita water availability of the state is 800cubic meters which is lower than the national average of 2300 cubic meters. The total surface water potential of the state is 36km^3. There are 17 major river basins in the state with 61 reservoirs and about 41,948 tanks of the annual water potential of 46540 million cubic meters (MCM) surface flows account for about half. Most of the surface water has already been tapped, primarily for irrigation which is the largest user. There are about 24 lakh hectares irrigated by surface water through major, medium and minor schemes. The utilization of surface water for irrigation is about 90 percent.

The utilizable groundwater recharge is 22,423MCM. The current level of utilization expressed as net ground water draft of 13.558MCM is about 60 of the available recharge. While 8875 MCM (40 percent) is the balance available for use. Over the last five years, the percentage of safe blocks has declined from 35.6 percentages to 25.2 percentages while the semi critical blocks have gone up by a similar percentage. Over exploitation has already occurred in more than a third of the blocks (35.8 percentage) while eight blocks (2 percent) have turned saline. The water level data reveals that the depth of the wells ranges from an average of 0.93 meters in pudukottai district to 43.43 meters in Erode. According to the Central Ground Water Board, there has been a general decline in ground water level in 2003 due to the complete desaturation of shallow aquifers. There has been a considerable failure of irrigation wells in Coimbatore district.

1.2 WATER RESOURCES OF INDIA

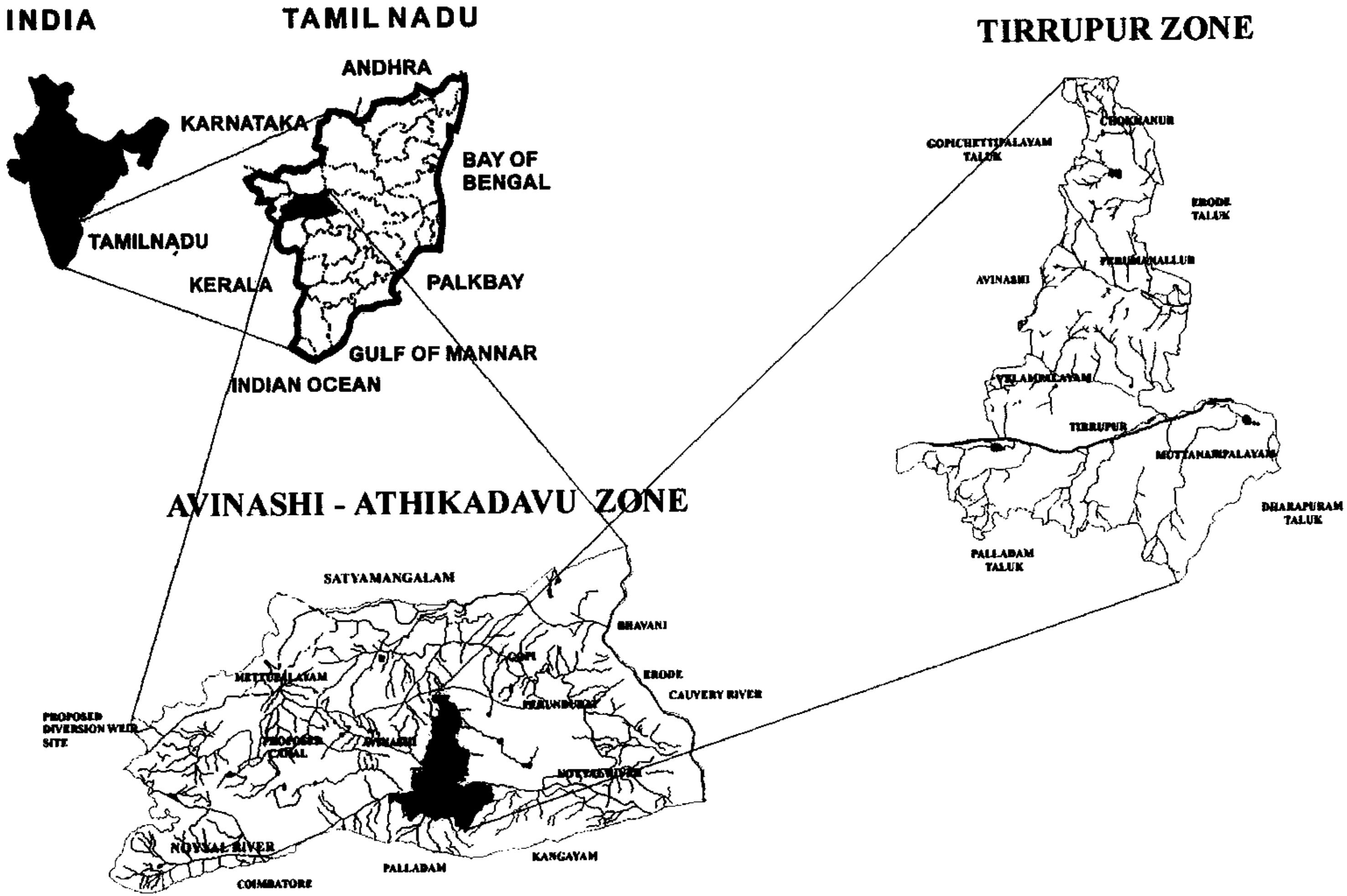
The annual rainfall of India is about 1194 mm. It contributes about 400m.ha m of water which, 125 m.ha m is lost as runoff, 70m.ha m as evaporation and the remaining infiltrates in to the soil including deep percolation loss. India is a monsoon country. South West Monsoon contributes 73.7% of total rainfall, whereas North East Monsoon accounts 13.3% of total rainfall. Rainfall is highly undependable and highly variable. In general, water resources in India are very unevenly distributed both spatially and temporally. Idiosyncrasies of monsoon and diverse physiographic conditions give rise to unequal distribution of water. Over the years, increasing population, urbanization and expansion in agriculture has accentuated the situation. The aftermath of unscientific exploitation of groundwater is that we are moving towards water stress condition. Even now, some parts of the country are facing acute water crisis. Despite being a very important part of the nation's growth, water resources analysis has been fragmentary.

1.3 STUDY AREA

The present study was taken up in Tiruppur district. Tiruppur district is the part of Avinashi-Athikadavu project. A weir is constructed in the path of Bhavani River. This diverts the water from the main stream to proposed canals. Even though this canals supplies water for Tiruppur district it has been found from the literature that ground water level is very low. In order to overcome this artificial recharge zones located using GIS. This helps when water deficiency is witnessed in Avinashi-Athikadavu project.

1.4 PROBLEMS IN STUDY AREA

When contaminants in groundwater exceed the levels deemed safe for the use of a specific aquifer, then the groundwater is considered polluted. There are three main sources of groundwater pollution. These include natural sources, waste disposal activities, spills, leaks, and non point source activities such as agricultural management practices. Here in Tiruppur area the groundwater quality is spoiled due to waste disposal activities, spills and leaks. Before the emergence of CETP and IETP, the Textile dyeing and bleaching industries were disposed the effluent into the river Noyyal without any treatment. The sludge generated was disposed by using sanitary landfill, and mostly by Open landfill method. These salts and chemicals leached from surface water to groundwater aquifer and resulted in problems for human consumption and even for agricultural activities.



1.a Index map of study area

The groundwater quality in and around Tiruppur was potable before 1990's. All the people used the groundwater for domestic purposes. The industrial communities were also utilized the groundwater for processing in their industries. The industrial communities were also utilized the groundwater for processing in their industries. But today the scenario is completely different. In many part of Tiruppur, groundwater usage is obsolete. The industrial people are transporting water from adjacent villages located 10 to 20 km away from Tiruppur. Even though the rainfall in mosoon months isadequate, the period of rainfall does not coincide with the period of maximum demand. These factors play an important role in planning and decision making of water resources for management problems. Therefore, artificial recharging of groundwater through rainwater harvesting is very important in areas undergoing the process of development to restore to some effect the disturbance in the hydrologic equilibrium

1.5 RAINWATER HARVESTING AND ARTIFICIAL RECHARGE OF GROUNDWATER

The term 'Rainwater Harvesting' implies conservation of rainwater. Catching rainwater when and where it falls for use during non-monsoon months is called rainwater harvesting. This can be done in two ways: as surface water by diverting the rainwater into tanks, ponds etc. or as ground water by ingesting rainwater through artificial recharging structures into the soil. Artificial recharge is the process of augmenting the natural movement of surface water into underground formations by some artificial methods. This is accompanied by constructing infiltration facilities or by inducing recharge from surface water bodies. In hard rock areas, the underlying lithological units do not have sufficient porosity and permeability. In these areas, groundwater recharge falls short of the water that is being taken out of the aquifers. Hence, groundwater cannot suffice the requirement for agriculture or drinking water. Thus, additional recharges by artificial methods become necessary to meet the water deficit.

1.6 NEED FOR RAINWATER HARVESTING AND RECHARGING

Following are some of the reasons for rainwater harvesting and recharging of ground water

- Rainwater is a source of fresh water on earth and if not harvested, runoff gets into the sea and gets wasted without augmenting the surface storage
- Failure to harvest rainwater will flood the low lying areas and cause lot of inconvenience
- It is the solution for water problems where there is inadequate ground water supply or insignificant surface resources or where rainfall is very intense only over short periods (say 3-4 months in a year)

1.7 SIGNIFICANCE OF RAINWATER HARVESTING

Earth is only blue planet, most part of it being dominated by water. However, 97.476% of the total water available on the earth is salty in nature and could not be used for human consumption. Out of the remaining 2.522%, about 69.56% is in the form of glaciers and permanent snow cover and 0.389% is available in the form of fresh water in lakes and rivers. This portion of fresh water is renewable but highly susceptible to pollution. However, 30.06% of fresh water is available underground. Ground water is dynamic and rechargeable. This form of fresh water is comparatively pure than river and lake water sources. Thus, it becomes imperative to harness available rainwater in an optimal way or else, it will go only waste in rivers and oceans. Proportion of available global water is shown in the figure 1.b.

1. b Proportion of available global water

1.8 GEOGRAPHIC INFORMATION SYSTEM

Water resources engineering involves processing of voluminous spatial data, which if processed manually is costly and time consuming. One such system that is having capabilities to handle a huge data is Geographic Information System (GIS). It is a system, capable of assembling, storing, manipulating and displaying geographically referenced information, i.e. data identification according to their location. GIS combines spatial database management, statistical analyzing and cartographic modeling capabilities within computer hardware and software configuration. Using the GIS, complex analysis between layers or maps has become possible. GIS is used here in this study to create the database, which is necessary to assess the groundwater potential and groundwater quality analysis.

1.9 SCOPE OF STUDY

The total study area of Tiruppur is 282km^2. Based on the annual average rainfall of Tiruppur as 524mm.This shows that there is a scope of artificial recharging of groundwater through rainwater harvesting and hence meeting the water requirements self sufficiently, if it is possible to find out either surface or subsurface storages or a combination of both, within the area.

1.10 OBJECTIVES

- To develop an integrated groundwater quality map of Tiruppur using GIS
- To estimate the ground water potential of Tiruppur
- To recommend the suitable artificial recharge structures for Tiruppur

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

2.1 GENERAL

The History of using computers for mapping and spatial analysis shows that there have been parallel developments in automated data capture, data analysis and presentation in several broadly related fields. GIS is information system that is designed to work with data referenced spatial or geographic c0-ordination and also with non-spatial data. In our fast changing world, rapid industrialization and explosive population have imposed serious unprecedented demands on natural resources, which are to optimally utilized. The GIS which is an effective tool for analysis and presentation of the geographic information, is a very valuable asset at this critical juncture where natural resources are depleting fast due to over exploitation

2.2 GEOGRAPHIC INFORMATION SYSTEM (GIS)

GIS is defined as a powerful tool for collecting, storing or retrieving, transforming the spatial information and arriving decision from the real world for particular set of purpose in real time, where the stored information are geo-referenced or geo-coded.

GIS is an information system that is designed to work with data referenced spatial or geographical co-ordination and also with non-spatial data. In a fast changing world, rapid industrialization and explosive population have imposed serious unprecedented demands on natural resources, which are to be optimally utilized. The GIS which is an effective tool for analysis and presentation of the geographic information, is a very valuable asset at this critical juncture where natural resources are depleting fast due to over exploitation.

The four functions of GIS are

1. Data acquisition and pre-processing
2. Data management storage and retrieval
3. Manipulation and analysis
4. Product generation

The GIS has the power of organizing effective Social Information System (SIS) towards decision-making or resource management. The spatial information system comprises synthesis of spatial formation and non-spatial data within GIS framework. The GIS aims and works at bringing together, the diverse information, which is gathered from various sources. Hence, this is also known as INTEGRATED ANALYSIS.

2.3 NEED FOR GIS

GIS continues to expand at an ever-increasing rate in almost all sphere of science, technology, planning and administration. Now GIS has wide application in myriad of physical and human endeavors like crime and disease analysis, routing of vehicles in case of traffic jams, business and industrial location analysis, urban and regional planning, military simulation etc.

A well-designed GIS should be able to provide the following facilities

1. Quick and easy access to large volumes of data
2. Ability to do the following
    a. Select the details by area or theme
    b. Link or merge one data with other
    c. Analyze spatial characteristics of data
    d. Search for particular characteristics or features in an area
    e. Updating data quick and economically, data modeling and assessment alternatively from time to time.

It is estimated that in developed countries, about 70 to 80% of the information maintained by government agencies is geographically referenced. In general GIS provides information on geographic elements or features such as locations, characteristics, logical and geometric relationship with other features and dependencies on other features. The GIS can be used as basis for tabular reports, output plots, spatial decision supports, trends analysis, etc.

Another important application area of GIS is one based on linear network like defining transportation routes, electricity distribution network etc. in the area of transportation the GIS provides ability to model individual road element and intersection and to analyze the routes between any two points within an urban street network for emergency services routes for ambulance and fire fighting vehicles.

GIS can be used to model utility networks such as water power and telecommunication to a large number of consumers with all the details of operational connections like the detailed inventories, layouts, transformers, values, conduits with schematic diagrams. Thus GIS becomes key elements at many levels such as customer's support incase of service failures, maintenance, daily operations, planning of project needs, etc. at a broad range of scales, maps have become important as legal documents that convey land ownership and jurisdictional boundaries, as tools to support decision making (for example, in urban planning) and as a means of visualizing multiple levels of information on political, social and ecological issues, for example, in thematic mapping of demographic data.

In addition to directly specifying spatial location on base map information, such element as taxpayer identifier, homeowner address, phone numbers and parcel numbers may be used as the spatial key. Perhaps for this reason, GIS is often seen as the means to promote information sharing, more efficient information management and maintenance and as a key to provide better and timelier services in a competitive environment. In addition, GIS is often both graphics and database intensive and provide strong visualization capabilities. The GIS is for time being still the printed map, but it is likely to be a cartographic product customized for a specific task or analysis, as opposed to a standard map series product.

2.4 APPLICATIONS OF GIS

GIS can play fundamental role in the application of spatially distributed data to Water Resources and Environmental Engineering fields with or without remote sensing data. The integration of GIS and data base management systems with help of computers, Water Resources and Environmental modeling and analysis of geographical data analysis will be fast and accurate.

- Use of Geo-informatics in planning the alignments of linear features like road, railways and canal etc. have become quite popular on the account of many commercial GIS and CAD softwares available in market
- Organizations like Survey of India, where the Digital cartographic Data Base (DCDB) is already available in 1: 250,000 scale, are using the Digital Elevation Model (DEM) for generating road and railway alignments and alternative route plans
- Geo-informatics and related GIS technologies have already being activated for sustainable environment planning, hazard predictions, its monitoring and planning of related mitigation programmes like predicting land slides, water quality monitoring, earthquakes, cyclones, natural resource management, routing and transportation applications etc.

2.5 DATA FOR GIS

GIS is intelligent if strong database is available. Data creation is the big task and 90% of time is spent for data creation only and analysis is done by mouse clicks. Paper maps from survey of India (SOI), NATMO, corporations, cadastral records, satellite imageries from various satellites, RADAR images, aerial photos, GPS observations and various attributes data of spatial and aspatial in nature are the inputs of GIS.

The following are the some of the widely used GIS software available in market

- Arc GIS 3.2 (from ESRI) consist of Arc Info 3.2, Arc View 3.2, Arc View 3.2, Arc View spatial Analyst, Arc View 3D Analyst, and Arc View Geo-statistical Analyst
- Map Info Professional 6.0 from Map Info Corporations

2.6 THREE VIEWS OF GIS:

Many have characterized GIS as one of the most powerful of all information technologies because it focuses on integrating knowledge from multiple sources and creates a crosscutting environment for collaboration. In addition, GIS is attractive to most people who encounter it because it is both intuitive and cognitive. It combines a powerful visualization environment with a strong analytic and modeling framework that is rooted in the science of geography. This combination has resulted in a technology that is science-based, trusted, and easily communicated across cultures, social classes, languages, and disciplines. To support this vision, GIS combines three fundamental aspects or views:

2.6.1 The geo database view:

A GIS manages geographic information. One way to think of a GIS is as a spatial database containing datasets that represent geographic information in terms of a generic GIS data model-feature, raters, attributes, topologies, networks, and so forth.

GIS datasets are like map layers; they are geographically referenced so that they overlay onto the earth's surface. In many cases, the features (points, lines, and polygons) share spatial relationships with one another. For example, adjacent features share a common boundary. Many linear features connect at their endpoints. Many point locations fall along linear features (e.g., address locations along roads).

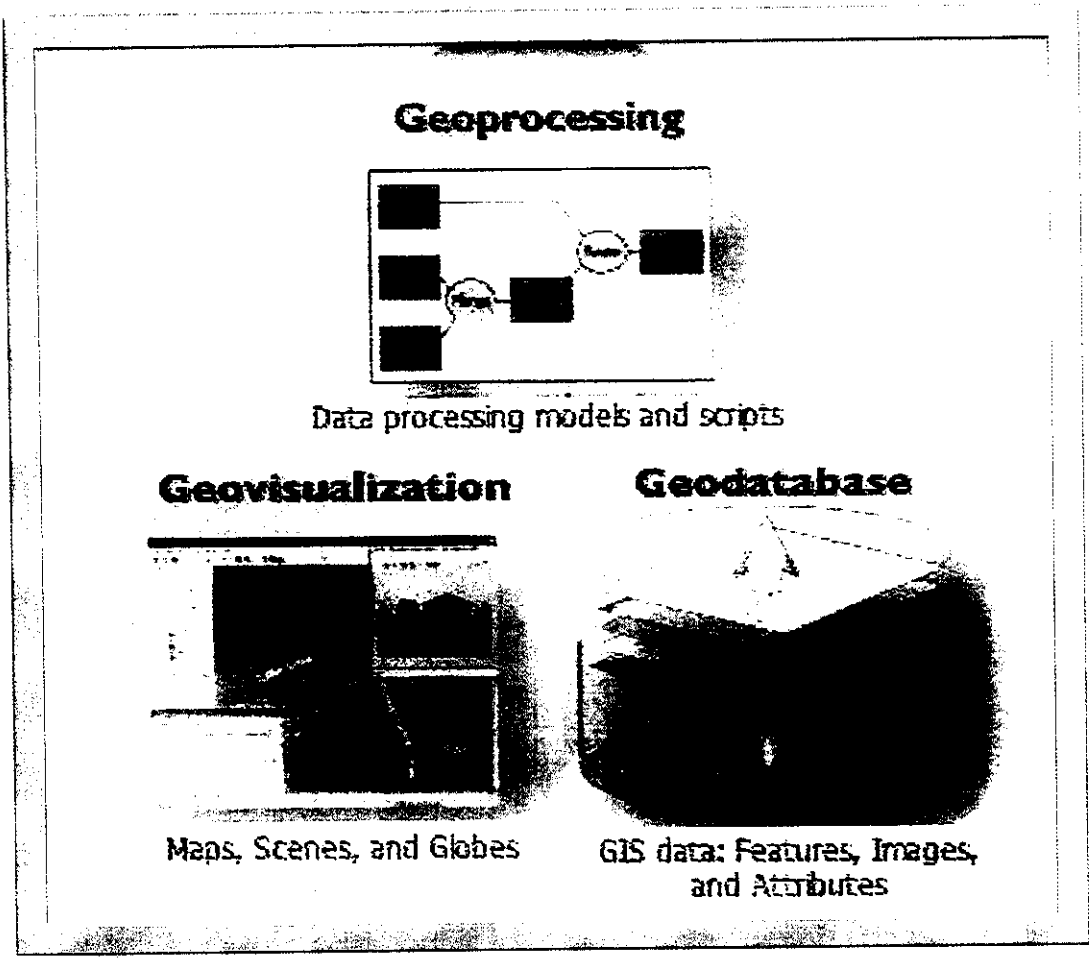
2.6.2. The map view:

A GIS is a set of intelligent maps and other views that show features and feature relationships on the earth's surface. Various map views of the underlying geographic information can be constructed and used as "windows into the geographic database" to support query, analysis, and editing of geographic information. Each GIS has a series of two-dimensional (2D) and three-dimensional (3D) map applications that provide rich tools for working with geographic information through these views.

2.6.3 The geo-processing view:

A GIS is a set of information transformation tools that derive new information from existing datasets. These geoprocessing functions take information from existing datasets, apply analytic functions, and write results into new derived datasets. Geoprocessing involves the ability to string together series of operations so that users can perform spatial analysis and automate ata processing all by assembling an ordered sequence of operations.

There are numerous spatial operators that can be applied to GIS data. The bility to derive new information within a GIS analysis process is one of the undamental capabilities in GIS. The three views of GIS is shown in figure 1.c.



1.c Three views of GIS

These three GIS views are represented in ArcGIS by the catalog and the geodatabase (a GIS is a collection of geographic datasets), the map (a GIS is an intelligent map view), and the toolbox (a GIS is a set of geoprocessing tools). Together, all three are critical parts of a complete GIS and are used at varying

2.7. COMPONENTS OF GIS

Software

- MapInfo Professional V 6.0
- Arc View 3.2

Data

- Data Creation and Representation
- Data transfer
- Projections, coordinate systems and registration
- Spatial analysis with GIS

2.8 GROUNDWATER ASSESSMENT USING GIS

Arora et al (2003) highlighted the use of Geographical Information System (GIS) in development of conceptual groundwater model. Various layers of information such as canal network, recharge zones, subsurface geology and digital terrain model (DTM) of Hanumangarh and Sriganagar districts were developed in GIS and were then transferred to finite difference grid for developing mathematical groundwater flow model of the area.

Arunet al (2003) developed an integrated remote sensing and GIS based methodology and tested for the evaluation of groundwater resources of Silai watershed, Bankura district, West Bengal.

Choubey (1996) stated that a rapid and accurate assessment the extent of waterlogged areas can be made using remotely sensed data. The waterlogged area was determined with the available water depth and electrical conductivity datas to assess the area sensitive to water logging.

STUDY AREA

3. STUDY AREA

3.1 GENERAL

Tiruppur is located 55 km to the east of Coimbatore city and accounts for 90% of India's knitwear export, worth an estimated of Rs 1,12,600 crores (2007). The town houses a population of 34,655|(as per Census 2001). It is India's largest producer of cotton knitwear, accounting for over three-fourths of the country's knitwear exports. The town has a unique significant presence at the lower end of the international hosiery and knitwear market. But the exports from knitwear are under threat due to the critical issues of environment pollution and water scarcity problems. Water is key to the operation of this industry. The city lacks adequate water supply and so the industries have turned to groundwater and private tanks for getting assured supply of water. The municipal areas also do not have a sewage collection and treatment system and an organized drainage system. Moreover, slum areas also lack adequate sanitation facilities.

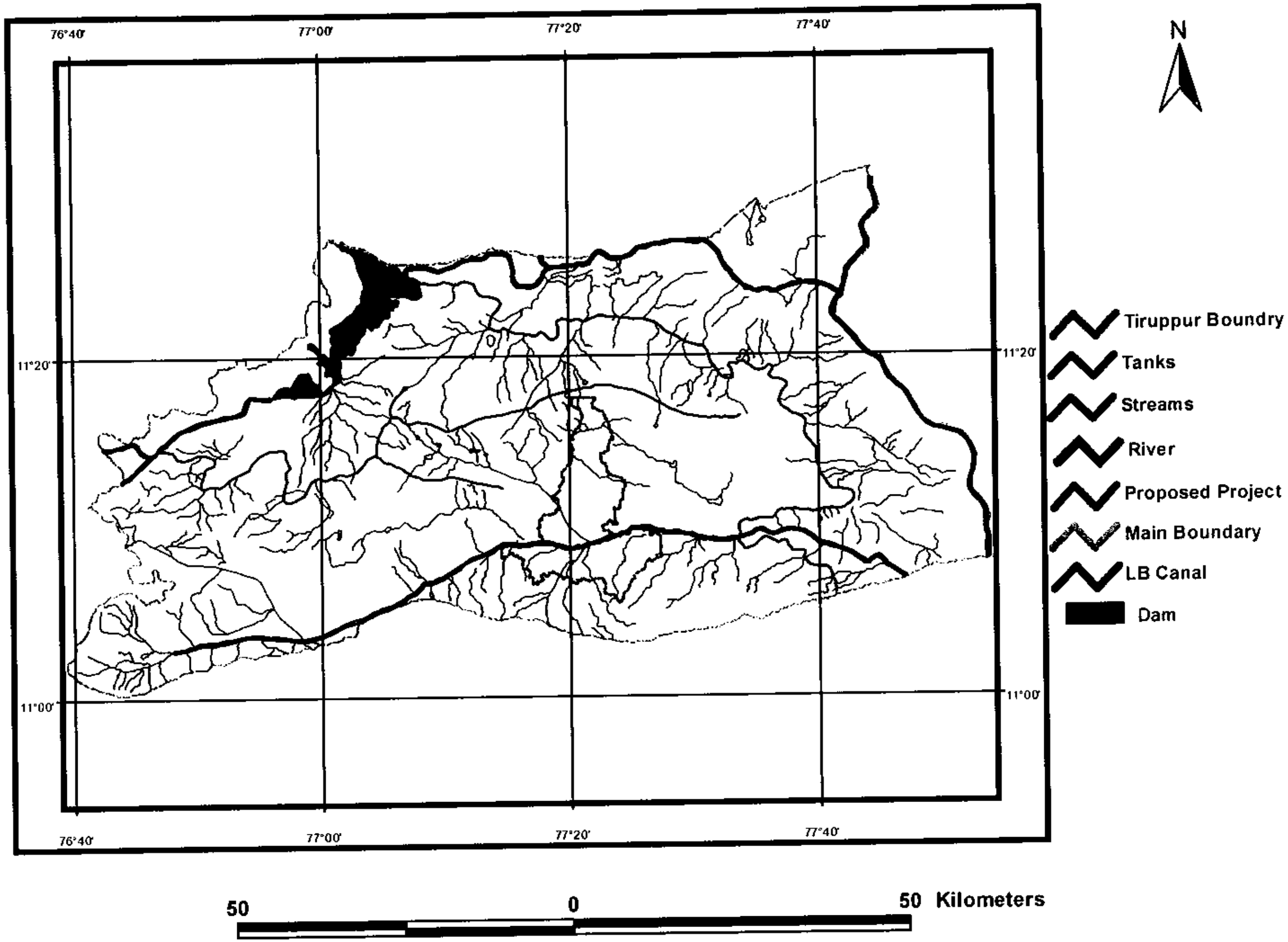
The reasons for the polluted ground water in Tiruppur are not hard to find. Every day, the textile industry uses 90 million litres of water and discharges 87 million litres of wastewater into a dry riverbed, from where it percolates into the underground water system. The ground water in Tiruppur is undrinkable because it is very saline and polluted with chemical dyes. Additional over 50,000 tons of solid waste produced every year lie in heaps in and around the city. The industries nearly 500-odd dyeing and bleaching units dump their effluents into the Noyyal river or throw them on the open wasteland. The Noyyal runs all across the 27 sq km town, virtually dividing it into two halves. According to reports from Tiruppur, about 12 lakh lie other hand, direct dischargetres of wastewater containing bleaching powder, sulphonic dyes and inorganic catalysts and other chemicals are discharged daily, 80% of which are drained into Noyyal. According to the reports from Tiruppur, Noyyal is now so terribly polluted thar it easily gets mistaken for huge multicoloured, half-dry gutter. On the other hand, direct discharge of effluents on the ground too has badly polluted and coloured the ground water table in Tiruppur. According to these reports, the pollution of Noyyal has badly hit even Cauvery and its tributary Bhawani. This has been shown in the figure 3.a.

As a result of the polluted groundwater, tankers bring water from farms up to fifty kilometers away and many farmers have now given up farming and instead supply water to industry. This has lead to mining of water in an unsustainable manner. Also, when the water gets too deep to be extracted, the farmers cannot get back to farming because the fields are too dry.

As the average rainfall in Tiruppur has come down for last few years, water scarcity is compensated by the ground water depression. So adequate awareness for increasing ground water storage is to be given by means of appropriate recharge techniques utilizing the surplus surface water.

3.2 LOCATION OF THE STUDY AREA

The study area for the project is Tiruppur. The Tiruppur lies between latitudes 10^0 51' and 11^0 79' and longitudes 77^0 14' and 77^0 30'. The index map of Tiruppur area and the district map are provided.



3.a Digitized map of Study area

3.3 RAINFALL DATA

Within the Tiruppur, the distribution of rainfall is uneven. The mean annual rainfall in this area is about 524mm. And a perusal of rainfall data collected over period of ten years from 1994 reveals that the district receives major portion of annual rainfall during the North East Monsoon.

South West Monsoon (June-Sep)...........110mm (21%)

North East Monsoon (Oct-Dec)..............264mm (50.3%)

Winter (Jan-Feb)................................16mm (3.1%)

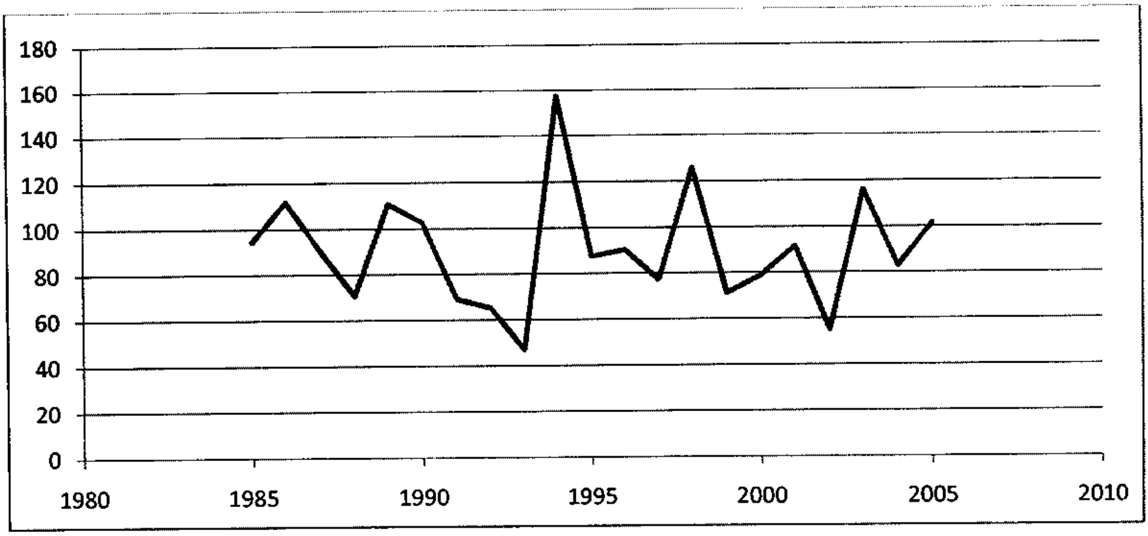
Summer(Mar-May)............................134mm(25.6%)

Mean Annual Rainfall.........................524mm

3.a Table Rain fall data for tiruppur from1985-2008

year	Annual rain fall
1985	94.183
1986	111.58
1987	90.443
1988	70.47
1989	110.65
1990	102.67
1991	69.23
1992	65.27
1993	46.95
1994	157.411
1995	87.58
1996	90.38
1997	77.1
1998	125.81
1999	70.98
2000	78.97
2001	91.62
2002	54.88
2003	116.04
2004	82.7
2005	101.53

3.a Variation of annual rainfall



3.4 IMPORTANCE OF THE STUDY

Excess abstraction of water for domestic and industrial supply and agricultural uses without proper planning and priorities will adversely affect the surface water. The ground water table is being depleted year after year due to the failure of monsoon, inadequate recharge of the aquifers and excessive pumping of water from the wells over and above the annual recharge into the aquifers. Proper watershed management has to be undertaken. As the Noyyal River is under depletion, it has to be safeguarded. As an initial measure for that, the watershed management should be carried out in the region of the Noyyal basin. Therefore various analyses should be made for the management of the surface and ground water resources of the watershed.

3.5 GROUNDWATER RECHARGING TECHNIQUES

The techniques of harvesting the rainwater can be successfully carried by various methods. The selection of a suitable rainwater harvesting method for any area depends upon many factors like hydrologic conditions, economic considerations, availability of land and topography, permeability of the soil etc. Thus the various methods adopted for rainwater harvesting are as follows

3.5.1 Open collection through sloped roof

This method is the commonly used form of direct rainwater harvesting system. Rain water cistern is a system of collecting and storing rainwater runoff from the roof tops in small tanks or vessels, under or above the ground. This is ideal for regions where ground water supply is inadequate and surface sources are either lacking or insufficient as in hill areas. Thus the rainwater is stored in under ground tanks for the domestic tanks

The various components used in this method are roof, gutters, drainpipes, storage tanks, filter medium, over flow pipes etc. The filter consist of granulated materials of various grades namely brick bats, sand and charcoal. In the case of a thatched house, polythene sheets can be used for collecting the rainwater.

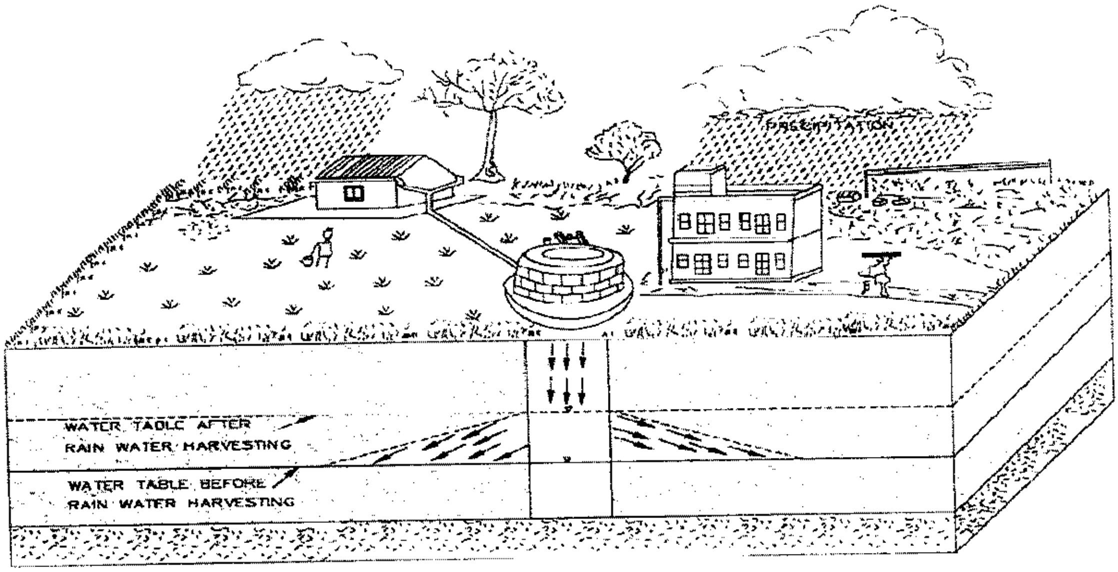


Figure 3.b Open collection through sloped roof

3.5.2 Open well method

In the case of an open well available with in the house, all the down take pipes could be connected and let the rainwater into either through a filter. This depends upon the quality and quantity of rainwater available in the existing well

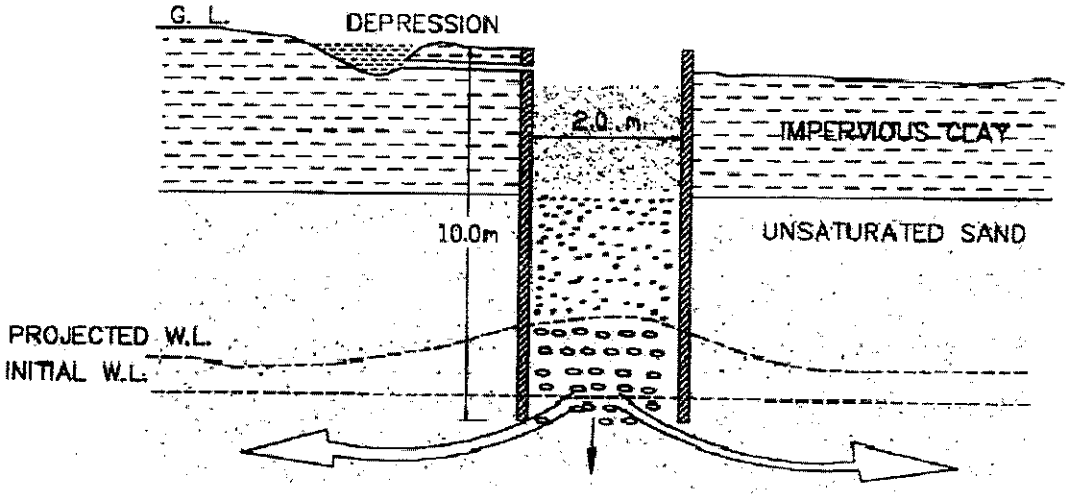


Figure 3.c Open well method

This method consists of two layers of granulated materials of different grade i.e. filled by brick bats in the bottom and the course sand on the top

3.5.3 Bore well method

In the case of a bore well available with in a house campus the harvested rainwater is diverted into bore wells in order to increase the water level so as to make use of the stored water effectively after proper filtration. The various components involved in this method are roof for the collection of rainwater, collection of pipes, filter chamber, filter materials, a deep bore well etc. The filter chamber is separated into two compartments. The finest compartments consist of two layers of granulated materials of different grade say brick at the bottom and sand layer at the top. The depth of sand layer should be 1/3 the depth of brick bat. The second compartment is kept empty so as to collect the filtered water from the finest compartment and diverting it to the bore well.

3.5.4 Recharge/Percolation Pit method

In this method the rainwater is recharged into the ground through the percolation pit. It may be square, rectangular or circular in shape. This method is best suitable for sandy subsoil areas. One unit of this percolation pit may be used for an area covering $25m^2$ in places where there is a paved path way to monitor this pit, this method can be adopted.

The required components for this method are the roof top, through which the rainwater is collected in pipes, percolation pit with broken bats, sand concrete slab for covering of this method. The rainwater that reaches the percolation pit through the collection pipes from the roof tops gets filtered in the process of following through layers and reaches the underground aquifers and recharges it.

3.5.5 Recharge Pit with bore method

In this method, an additional bore hole is provided along the percolation pit. When the depth of clay subsoil is more, recharge of ground water through percolation pit with bore holes is preferable. The depths of bore holes are about 6.0 m tp 8.0 m and can be in the shape of rectangle or square or circle. This method can be adopted for two storey or three storey building

The various components involved in this method are open terrace through which rainwater is collected, storm water pipes percolation pit with bore holes, broken bit bats pebbles. River sand perforated concrete slab acting as screen. The rainwater collected from open terrace reaches the percolation pit through those storm water drainage pipes. This water gets filtered as it passes through the filter materials and increases the ground water table.

3.5.6 Recharge trench method

This method of recharging the ground is similar to the percolation pit method but the difference is that it is constructed longitudinal in shape. The width of the trench may be of 0.3m * 0.9m. This method of ground water recharging is best suited for the places where sandy sub-soil is found.

Based on the catchments of the roof, one or two units can be provided. The various components involved in this method are the open terrace through which the rainwater is collected, storm water pipes, recharge trench, perforated concrete slab, sand and brick bats. The rainwater collected on the open terrace is diverted into the trenches through the storm water drainage pipes. This diverted water is filtered by means of the filter materials in the trench and reaches the ground water table leading to the method increase in ground water level.

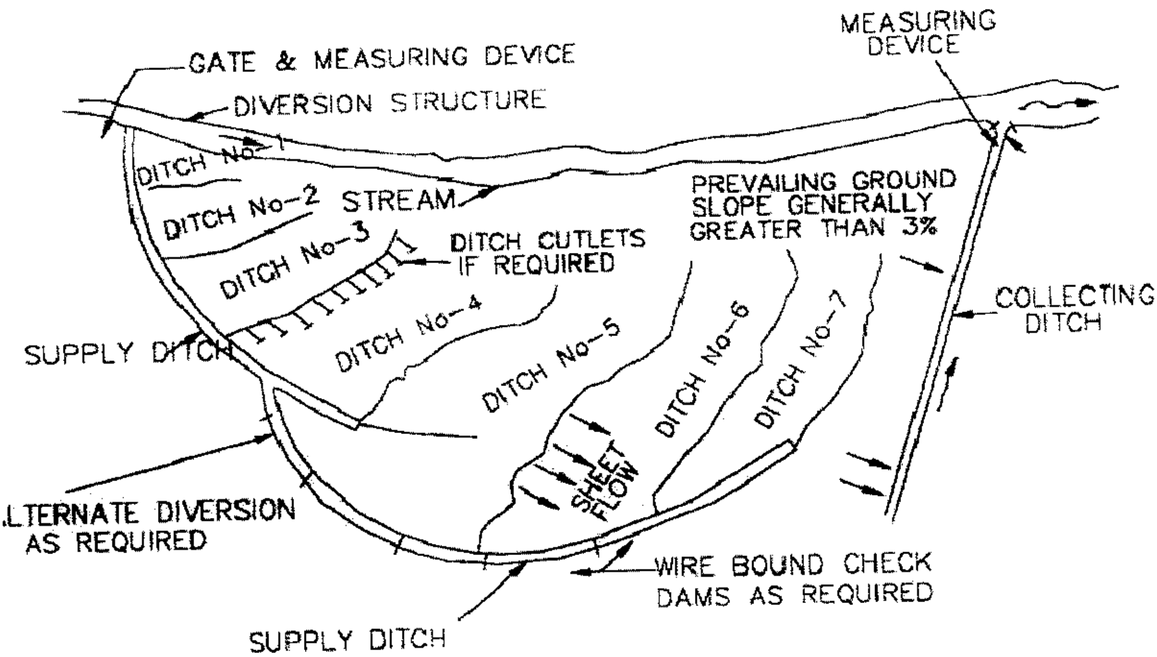


Figure 3.d Recharge trench method

3.5.7 Recharge trench with bore method

In this method the bore holes are drilled in addition to the recharge trench. This method is one of the mostly ideal recharge structures in limited open land, narrow street etc. a number of shafts are provided inside the trench depending on the sub surface formation and the availability of water. This method is best suitable for clayey sub soil condition.

The various components of this method are the air vent, storm water pipes, slotted pipes, recharge trench, unlined bore wells coarse sand and pebbles. The rainwater from the open terrace is diverted to slotted pipes in trench through the storm water pipes. The diverted water is passed through the filter materials from the slotted pipes and gets filtered.r.

3.5.8 Recharge well method

This method of rainwater harvesting is meant for areas with large catchments like apartments and big complex buildings. It is best suited for snady sub-soil area. In this method a deep bore well is constructed. The various components of this method are roof through which rainwater is collected, collected pipes, granular materials of various grades, concrete cover slab, vent pipes etc..

The water from the top is drained into the recharging well through number of drain pipes. The collected water in the recharge well is passed through the bore well and level of water table.

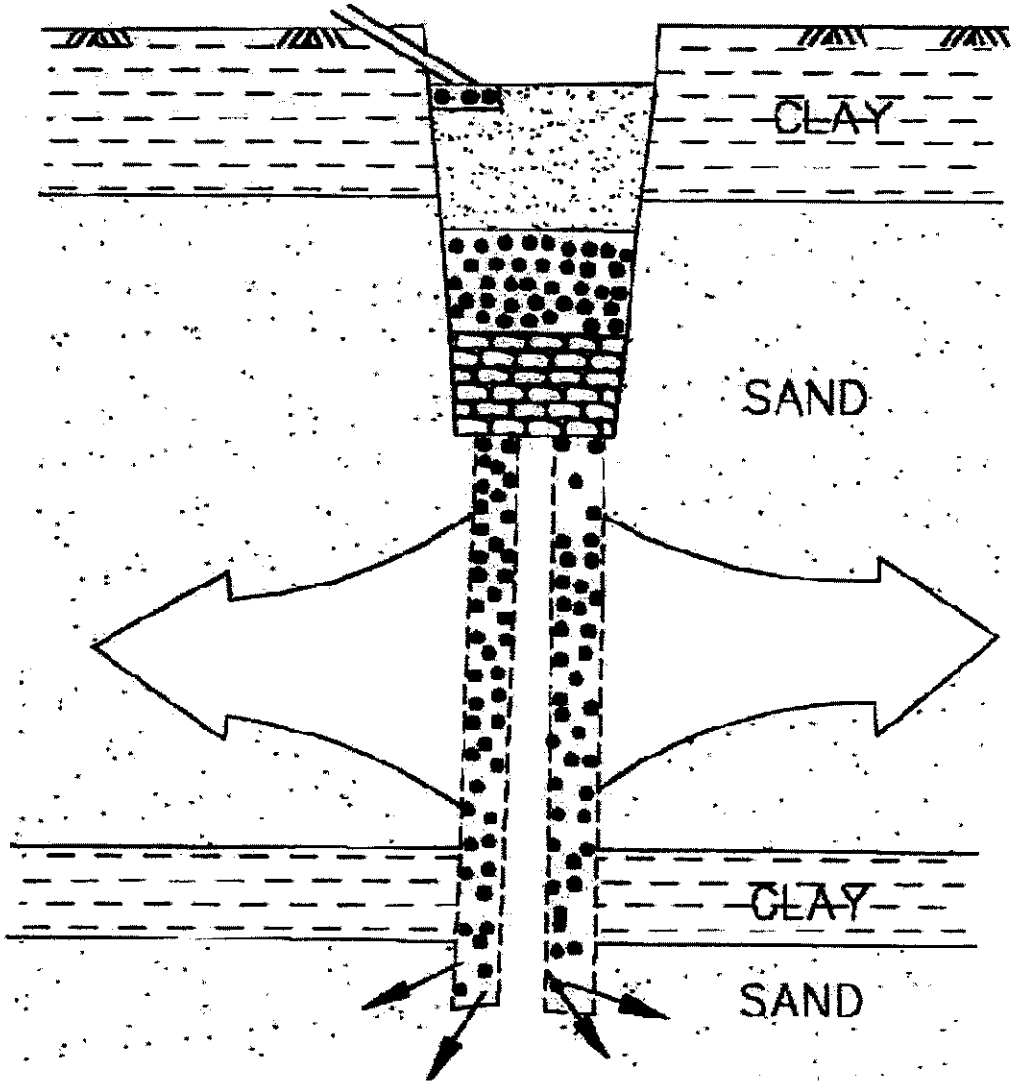


Figure 4.e Recharge well method

METHODOLGY

4. METHODOLY

4.1 GENERAL

The groundwater quality analysis and water resources assessment for the study area is discussed in following topics. Input data used and database created using GIS for these studies are presented below. Curve number values are used to assess the Surface runoff potential of the study area. In this study, Criterion tables based on the various themes were used to recommended suitable artificial recharge locations for Tiruppur. Integrated Groundwater quality map was prepared from the well water level data by using Arc view, GIS package.

4.2 METHOD OF USING GIS

4.2.1 Input data

The following thematic maps were digitized to create each as separate layer using Arc View GIS package

- Rivers and streams map
- Soil map
- Slope map
- Geology/Geomorphology map
- Land use

4.2.2 Creation of database

The maps were digitized using MAP INFO and topology creation was done using ARC-INFO. The coverage then projected to a real world co-ordinate system. For this study, polygenic projection was used to project the coverage. The database created will be in the form of polygon attribute table. Necessary items for analysis were added to the coverage using tables. With the help of tables, overlaying analysis like updating, union, intersection, identifying the features was made possible

4.2.3 Conventional Database

The following are the conventional database

- Rainfall Data
- Water quality data
- Layout map of Tiruppur

4.3 DIGITIZATION OF MAPS

Digitization is the process of capturing the spatial data on a map manually and storing them into a computer file. The spatial features, namely points, lines, polygons that constitute a map, are converted into x and y coordinates. The digitized map is called as a thematic map. The GIS software used for digitization and spatial analysis in the present study are Mapinfo version 6.0 and ArcView 3.2a.

Mapinfo, is a vector based software with limited map analysis capabilities. It is used for geo-referencing and digitization of the collected map. ArcView 3.2a, is a vector based GIS package developed by the Environmental Systems Research Institute (ESRI), Reblands, California. It is capable of accessing large amount of spatially varying data. It is used to create the spatial database, analysis and produce the outputs for the present study.

4.4 THEMATIC MAP PREPARATION

Thematic maps are an important source of GIS information. These are tools to communicate geographical concepts such as climate, forests, land use pattern, soil type, roads and political boundaries etc.

Thematic map displays the spatial pattern of a theme or series of attributes. The following thematic maps were prepared for this study.

1) Drainage map
2) Soil map
3) Land use map
4) Geology map

The drainage map includes the drainage lines, river and its distributaries, tanks and watershed boundaries, which is considered as a base map of the study area. Based on the base map, the other maps like soil, land use pattern, geology, geomorphology, lineament and toposheet were geo-referenced by latitude and longitude, subsetted and digitized using Mapinfo software. These maps were exported to ArcView 3.2a for spatial analysis and their outputs are given below.

4.4.1 Drainage Map

The drainage map has been prepared from watershed map at 1:50,000 scale. The drainage network and location of tanks were digitized and converted into the thematic map as presented in Figure 4.a. The small thickness lines are representing the drainage lines while larger thickness line representing the river.

4.4.2 Hydrological Soil Group

The study area is predominantly covered by red soil. From the soil series map, the hydrological soil group was identified. Hydrological soil group B and D were identified in the study area and is shown in Figure 4.b.

The area of soil hydrological group B and D obtained through GIS are 96.26 and 11.34 km^2. The maximum area of watershed was observed to be under hydrological soil group B (89.46%) followed by hydrological soil group of D (10.54%). Hydrological soil group of the study area is shown in Table 4.a.

Table 4.a Hydrological soil group present in the study area

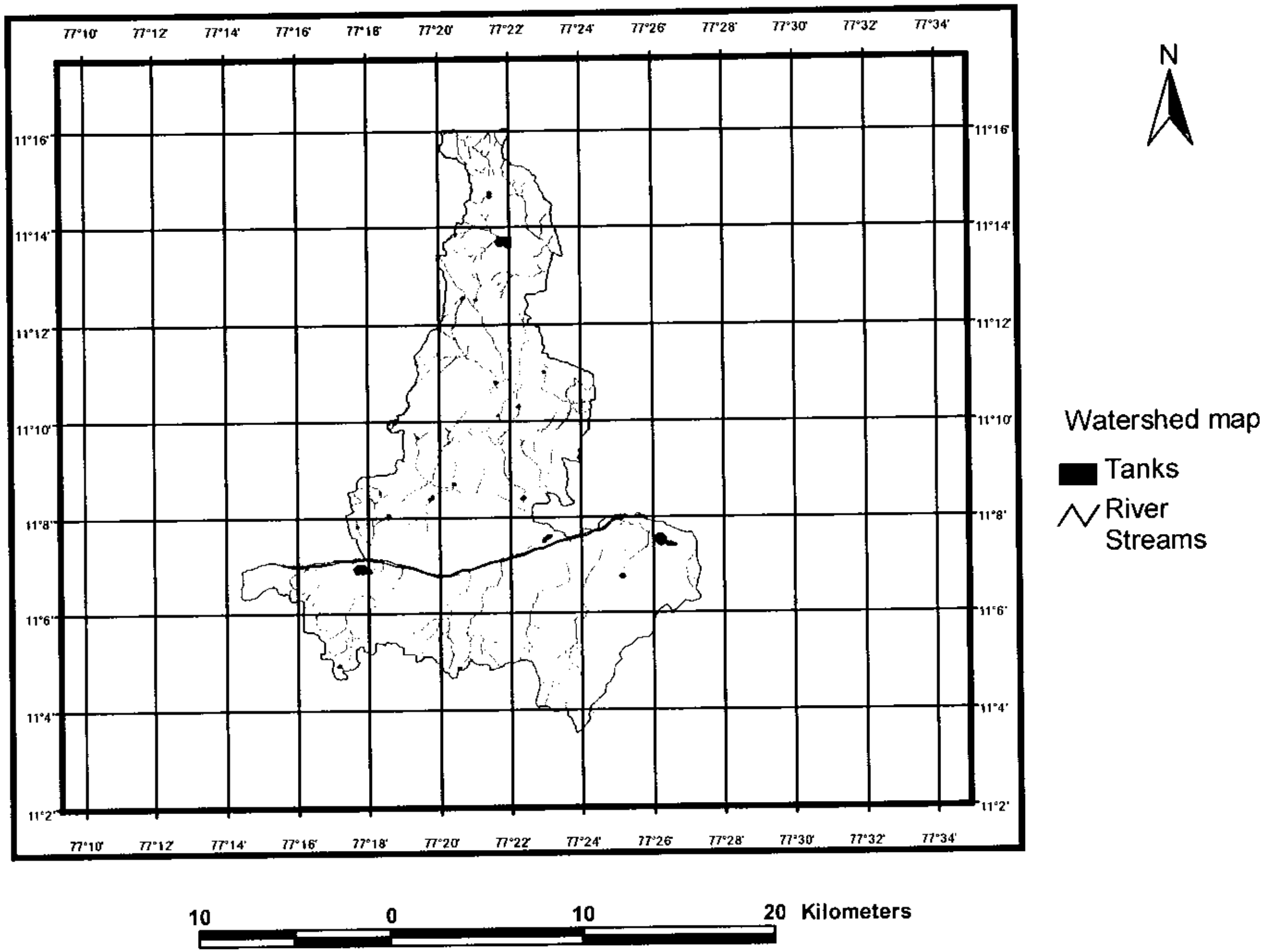
Sl.No	Hydrological soil group	Area (km^2)	Area (%)
1	B	122.002	43.23
2	C	62.955	22.31
3	D	97.251	34.46
	Total Area	282.208	100

4.4.3 Land Use Pattern Map

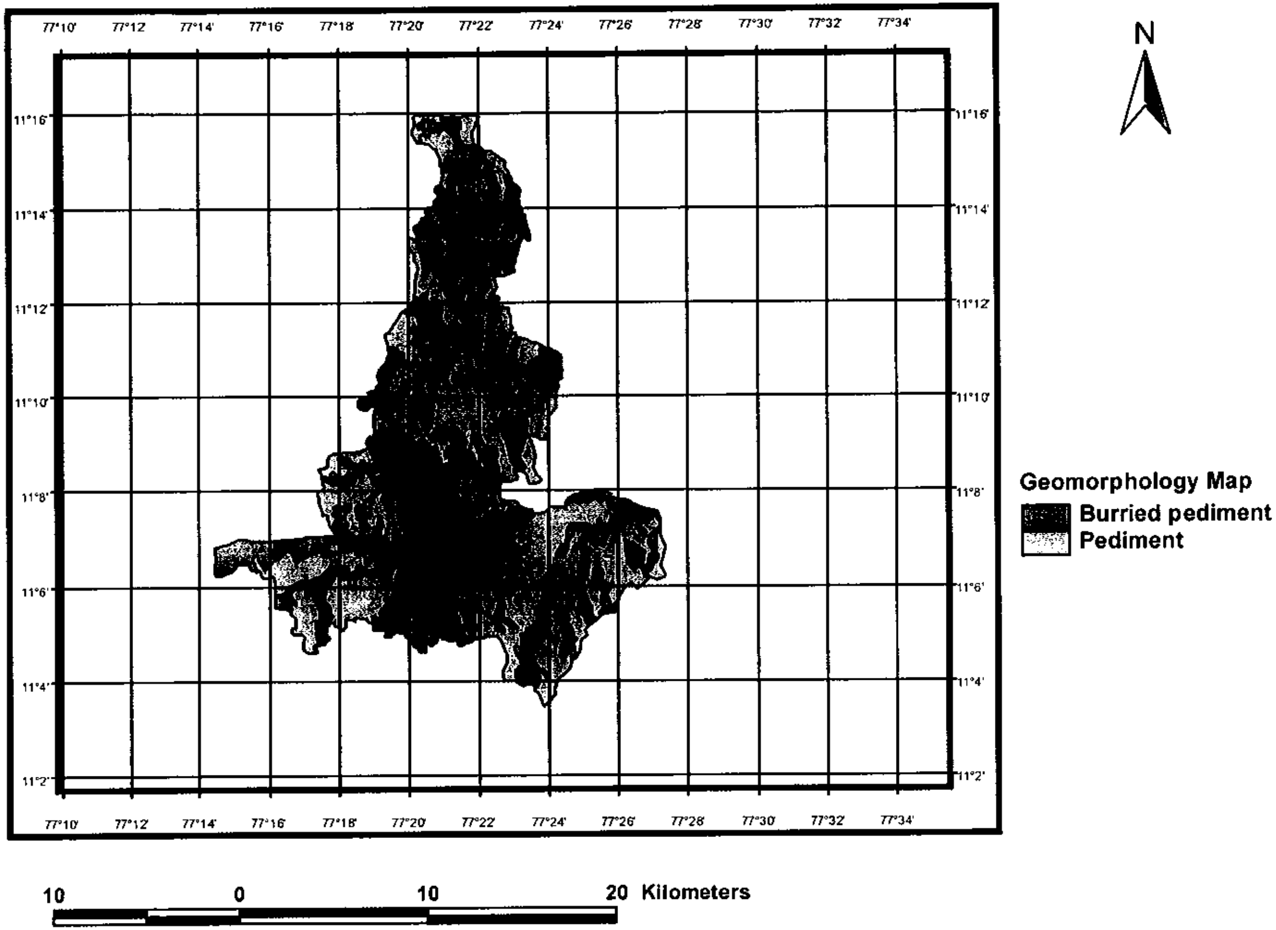
The major area of the sub-watershed is under agricultural cropland. Seven types of land use pattern were identified in the watershed such as hills/rocks, built up lands, water bodies, cultivable lands, mining, agricultural land and salt affected area. The land use pattern map is shown in Figure 4.c.

4.4.4 Geomorphology

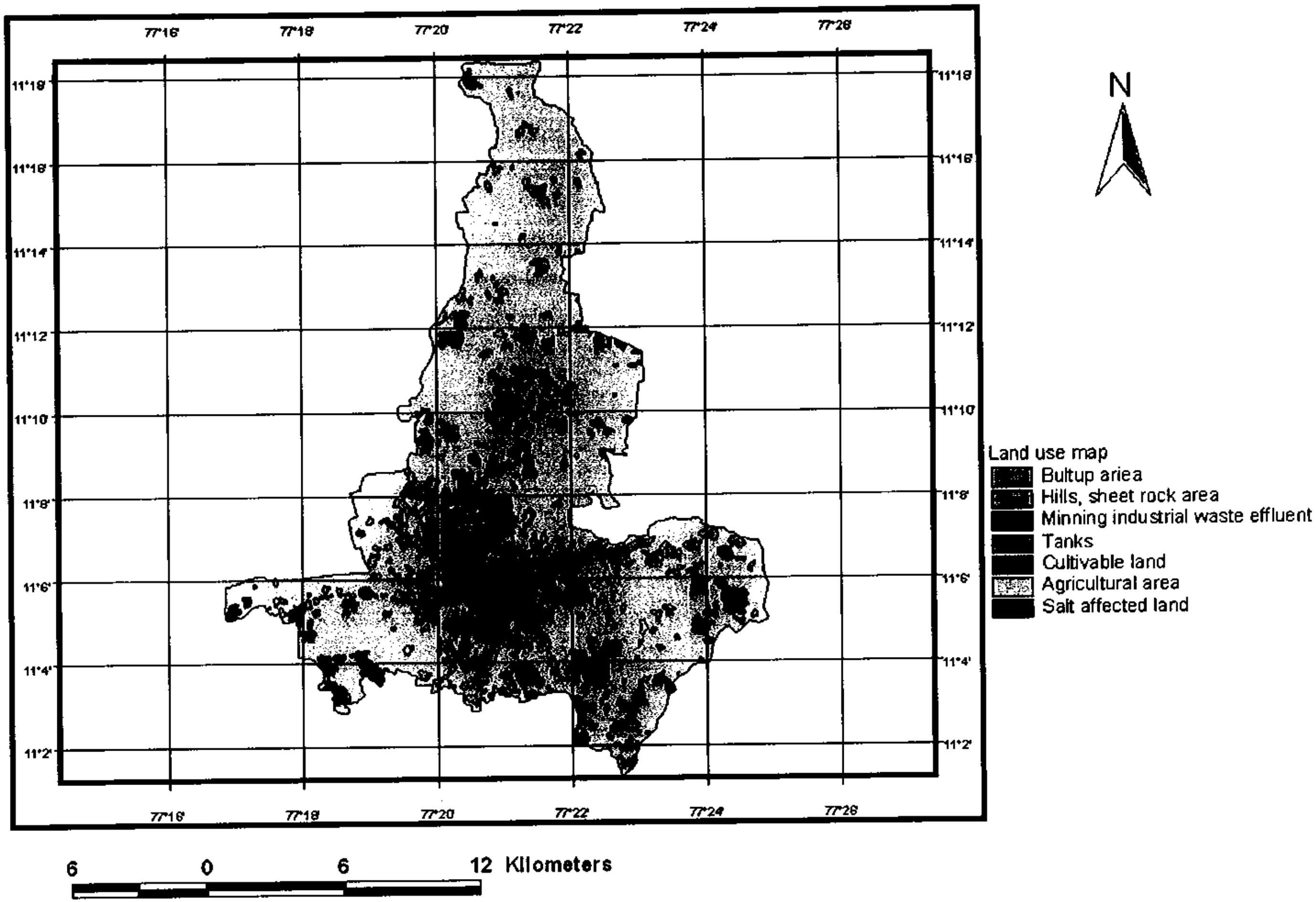
Geomorphology is one of the main controlling factors of groundwater. Geomorphological maps help to identify the various geomorphic units and groundwater occurrence in each unit. The major geomorphic units identified in this study area are Pediment-Inselberg complex (PI) and Buried Pediment Shallow (BPS). Geomorphological map of the study area is shown in Figure 4.d.



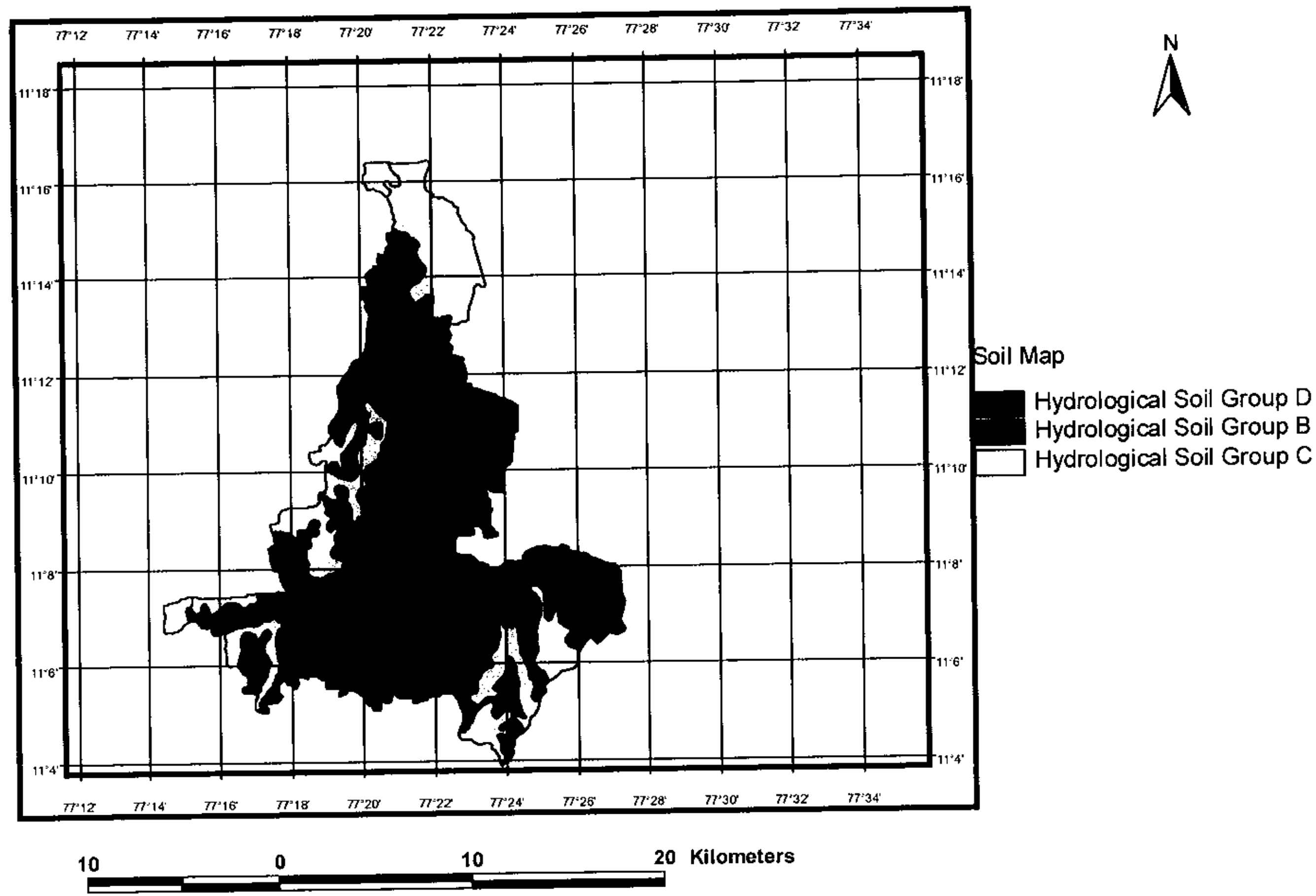
4.a Digitized Drainage map of Tiruppur district



4.d Geomorphology map of Tiruppur district



4.c Land use map of Tiruppur district



4.b Hydrological soil group map of Tiruppur district

4.5 OVERLAYING OF THEMATIC MAPS

Overlaying is an important procedure in GIS analysis. To identify overlaying results one or more thematic maps within single unique format thematic maps were overlaid. Due to overlay, the thematic map and their attributes were intersected and gave the superimposed map and their attributes.

4.6 GROUNDWATER RECHARGE POTENTIAL ZONING

The primary task in groundwater management of a watershed is to identify regions of high, medium, low, and very low groundwater recharge potential zones using GIS approach. Groundwater recharge potential depends on watershed characteristics like geology, geomorphology, soil, slope, runoff, lineaments and land use.

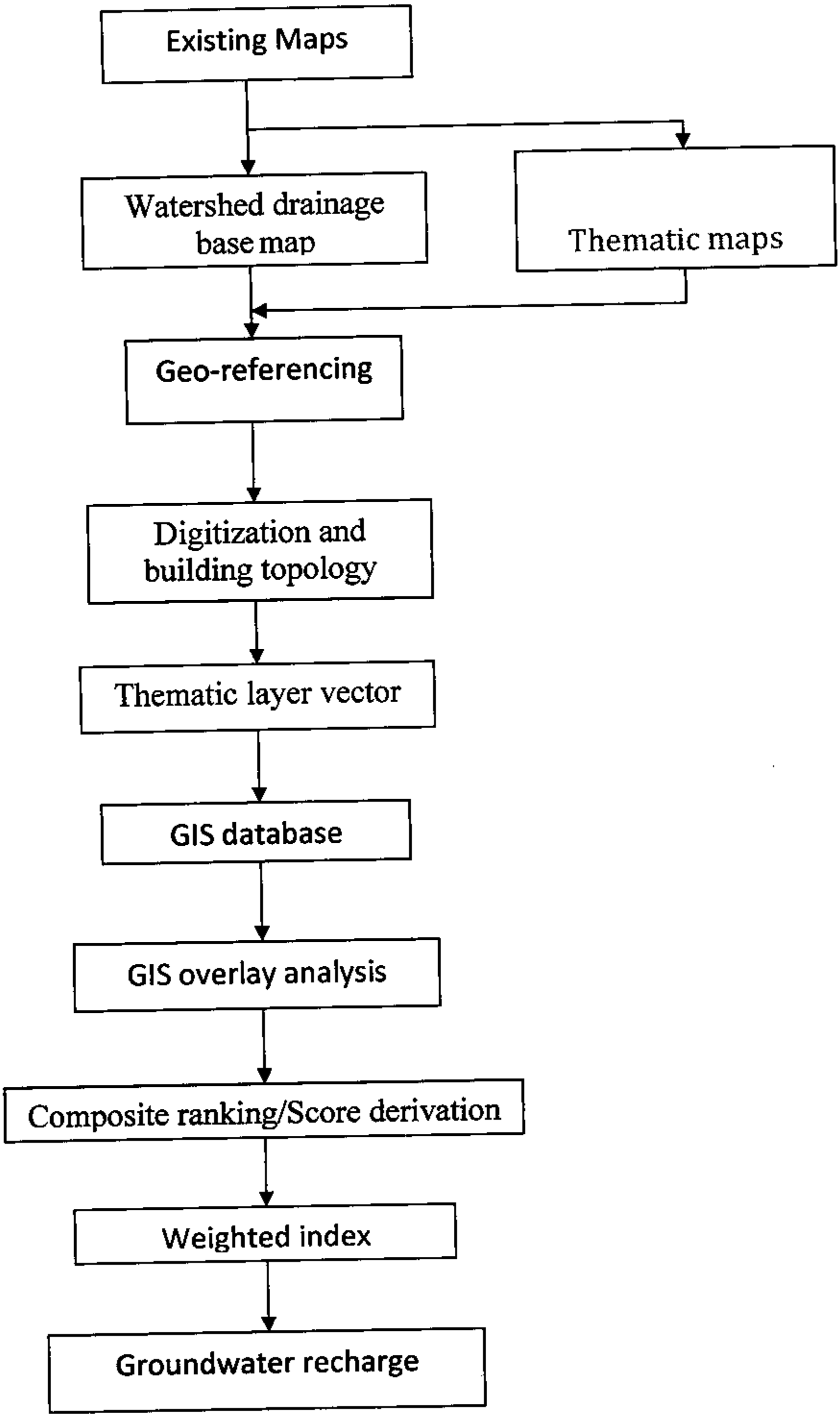
All the maps were georeferenced and digitized using Mapinfo software and exported to ArcView 3.2a software for spatial analysis. The above themes have been integrated and converted into grid with their corresponding weightage supporting groundwater recharge potential by using Model builder option in ArcView 3.2a software. Finally, the entire model is run by using weighted overlay method. The methodology adopted in the study to delineate groundwater recharge potential zones is presented in Figure 4.e.

4.7 Weighted Index Overlay Analysis (WIOA)

Weighted Index Overlay Analysis (WIOA) is a simple and straightforward method for combined analysis of multi class map. In this method, weights have been assigned to various classes of different themes like geology, geomorphology, land use pattern, soil type, slope and runoff according to the importance of these classes supporting groundwater recharge.

The weightage of each criterion was finalized on the basis of the ranges of the maximum and minimum values within each theme. Total weightages were divided into different potential zones such as good, moderate, poor and very poor depending on the final weight values assigned to polygons in the final layer.

METHODOLOGY



4.8 SELECTION OF SUITABLE SITES FOR ARTIFICIAL RECHARGE

GIS based methodology is found to be very useful in suitability analysis for artificial recharge sites in the hard rock terrain The areas favourable for different methods of artificial recharge are first demarcated based on the groundwater recharge potential zone map. The maps exhibiting the zones of high and moderate recharge potential are considered as favourable sites for artificial recharge. The drainage pattern map is superimposed over the groundwater recharge potential map and used to identify site-specific mechanism for artificial recharge for the sub-watershed.

WATER QUALITY FOR AREAS UNDER AVINASHI- ATHIKADAVU SCHEME

5. WATER QUALITY FOR AREAS UNDER AVINASHI – ATHIKADAVU SCHEME

GIS is used to evaluate the quality of groundwater in Tiruppur talk. Spatial variation map of major water quality parameters like pH, EC, Chlorides, Sulphates, TDS, Total hardness were prepared for Tiruppur talk. Based on these spatial variation maps of major water quality parameters, an Integrated Groundwater quality map of Tiruppur talk was prepared using GIS. This integrated Groundwater quality map helps us to know the existing groundwater condition of the study area

The pH values were categorized to three ranges: 6-7.5, 7.5-8.5 and > 8.5. based upon these ranges the spatial variation map for pH in Open wells and bore wells were prepared and presented. From the map, it has been observed that the maximum area pH value is in the range of 7.5 – 8.5 and the areas in the range of 6 – 7.5 and >8.5 are in the same proportion.

The Electrical Conductivity (EC) was classified in to three ranges 0 – 2250 μmhos/cm, 2250 – 3000 μmhos/cm, > 3000 μmhos/cm. From the map it has been observed that the EC value of 0 – 2250 in the most part of Tiruppur talk. The other values are in the scarce regions of the district.

The chlorides was classified into three ranges 0 – 250 mg/L,250 – 750 mg/L, > 750 mg/L. Based on these values the regions have been identified. The most part of Tiruppur talk have chloride concentration in the range of 250 – 750 mg/L.

For TDS it has been classified in the range of 0 – 1000 mg/L, 1000 – 2100 mg/L, >2100 mg/L. For most part of the Tiruppur talk the TDS is in the range of 1000 – 2100 mg/L. The region with TDS of >2100 is scarce.

In case of sulphates, the region has been classified as 0 – 250 mg/L, 250 – 500 mg/L and >500 mg/L. For most part of Tiruppur the sulphates are in the range of 0 – 250 mg/L.

The range of Calcium has been classified as 0 – 60 mg/L, 60 – 120 mg/L and > 120 mg/L. Most of the Tiruppur have calcium in the range of 0 – 60 mg/L. The range of Magnesium has been classified as 0 – 100 mg/L, 100 – 200 mg/L and > 200 mg/L most part of Tiruppur talk has Magnesium concentration of 0 – 100 mg/L.

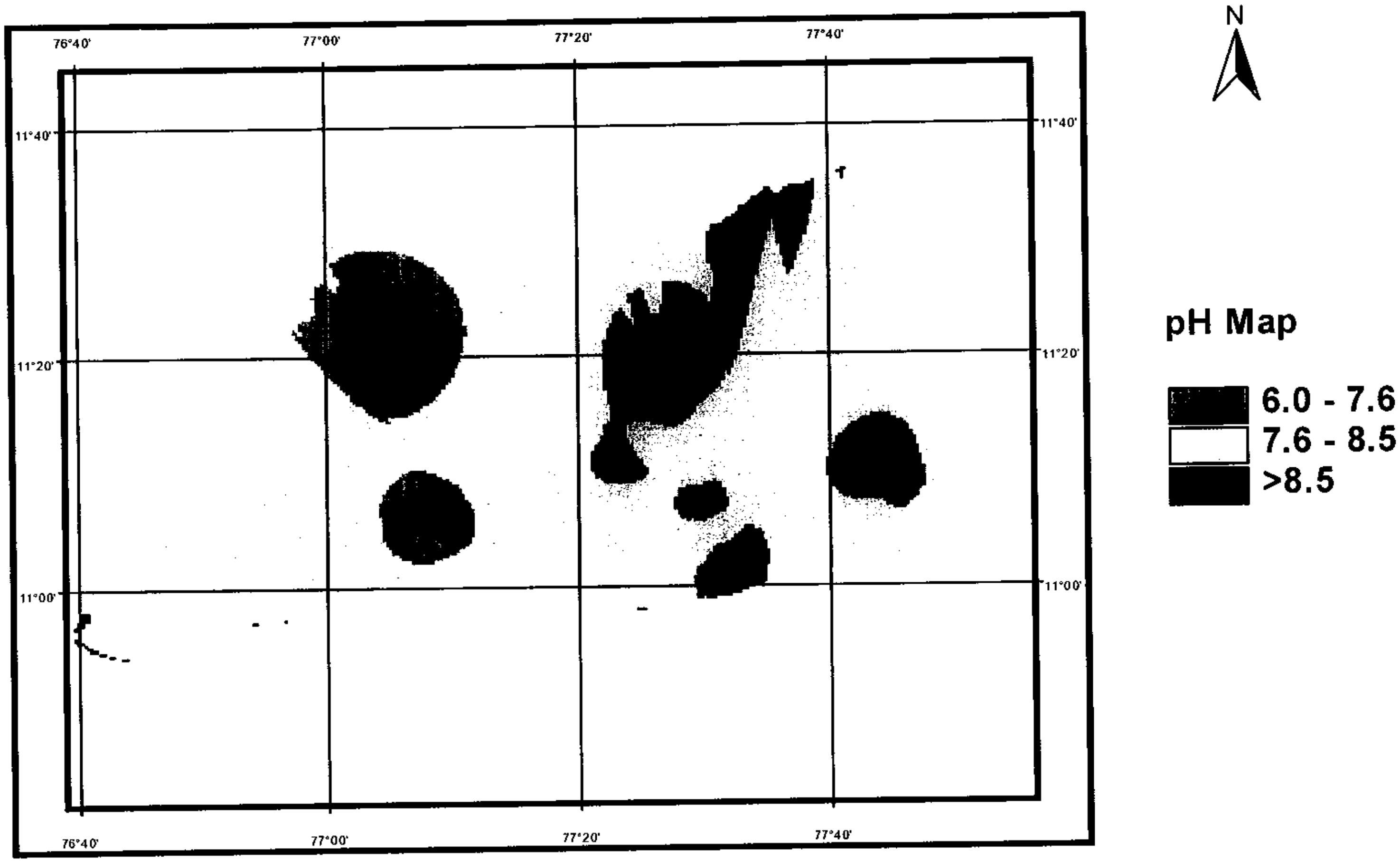


Figure 5.a Spatial variation map of pH for Avinashi-Athikadavu scheme zone

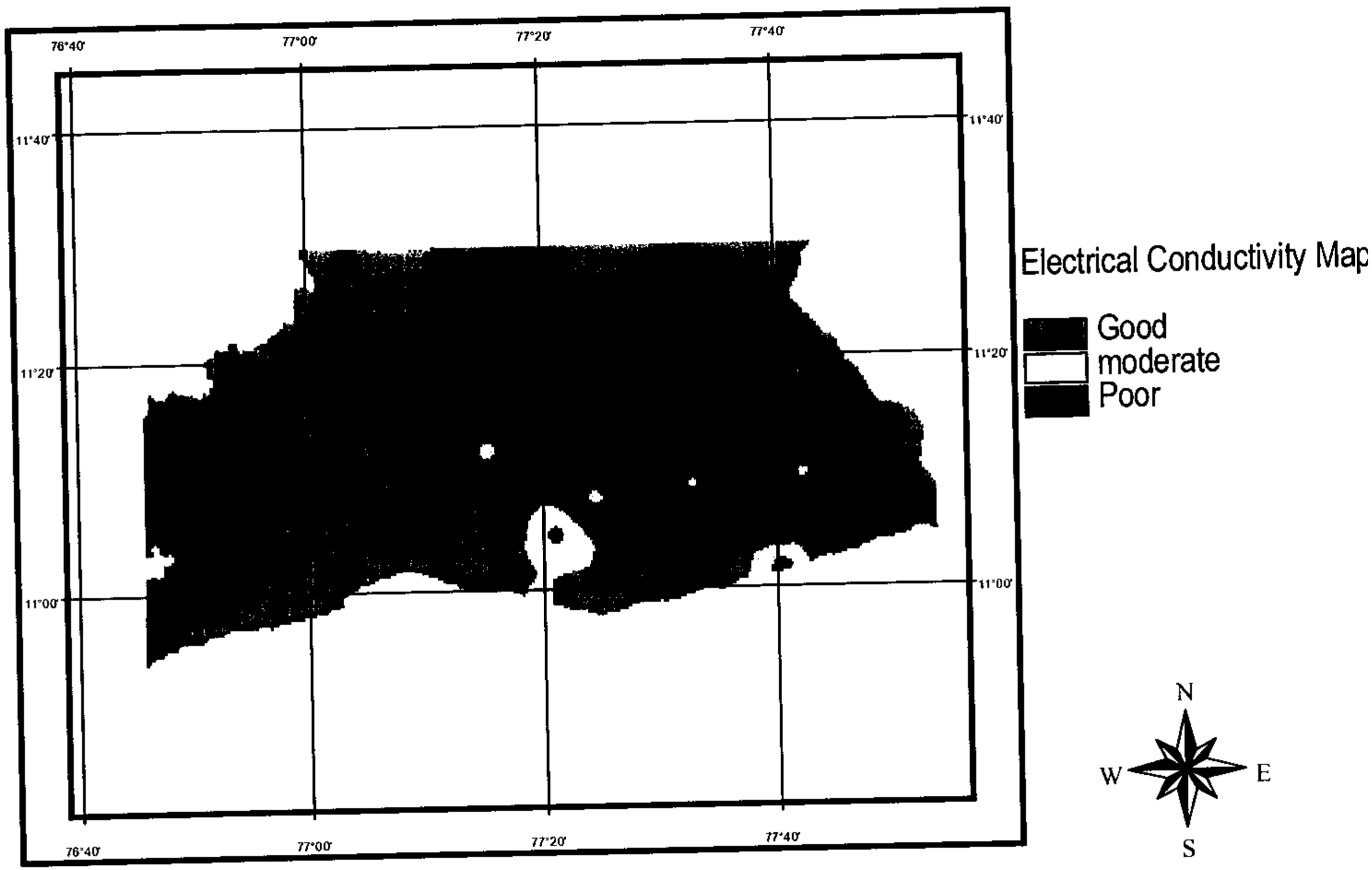


Figure 5.b Spatial variation map of pH for Avinashi-Athikadavu scheme zone

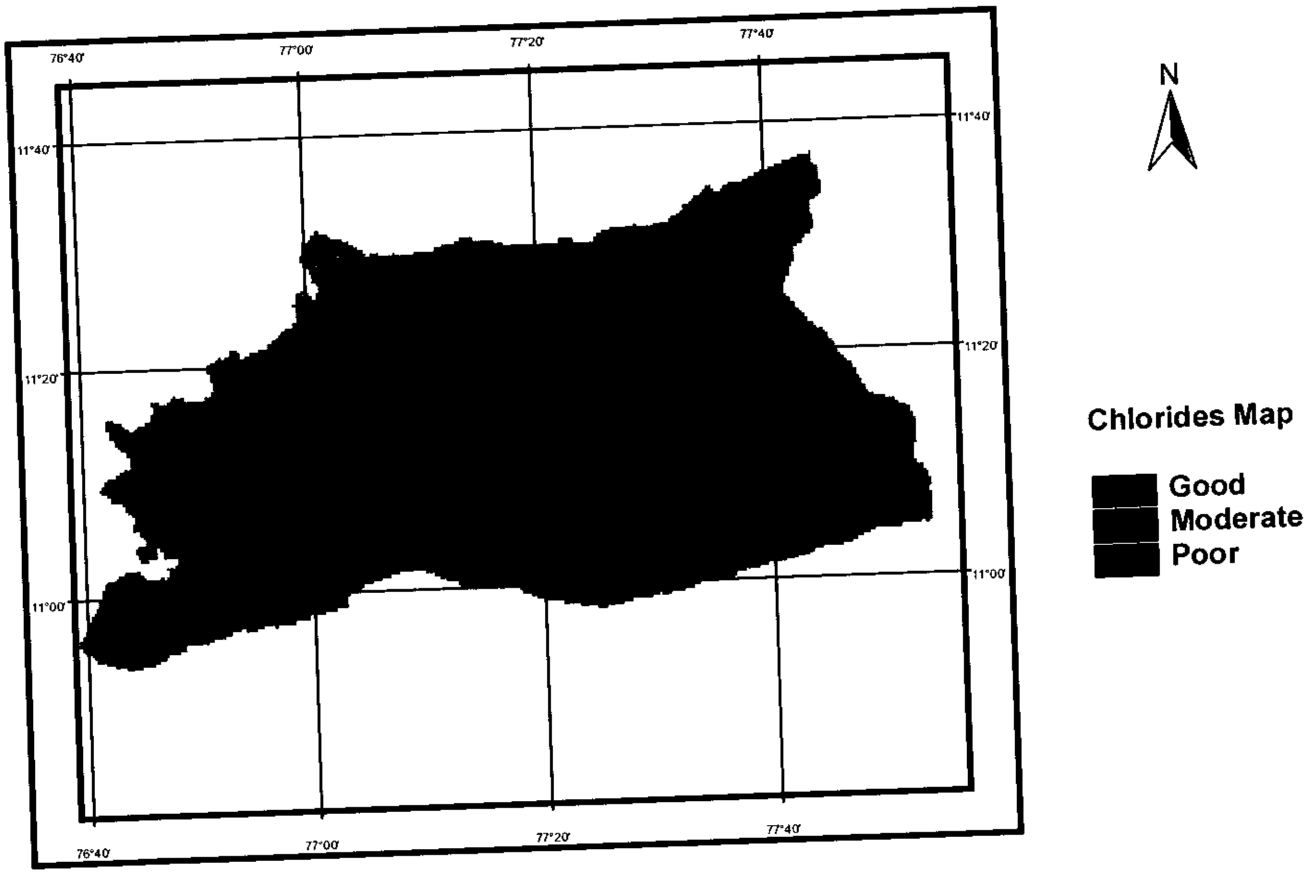


Figure 5.c Spatial variation map of Chlorides for Avinashi-Athikadavu scheme zone

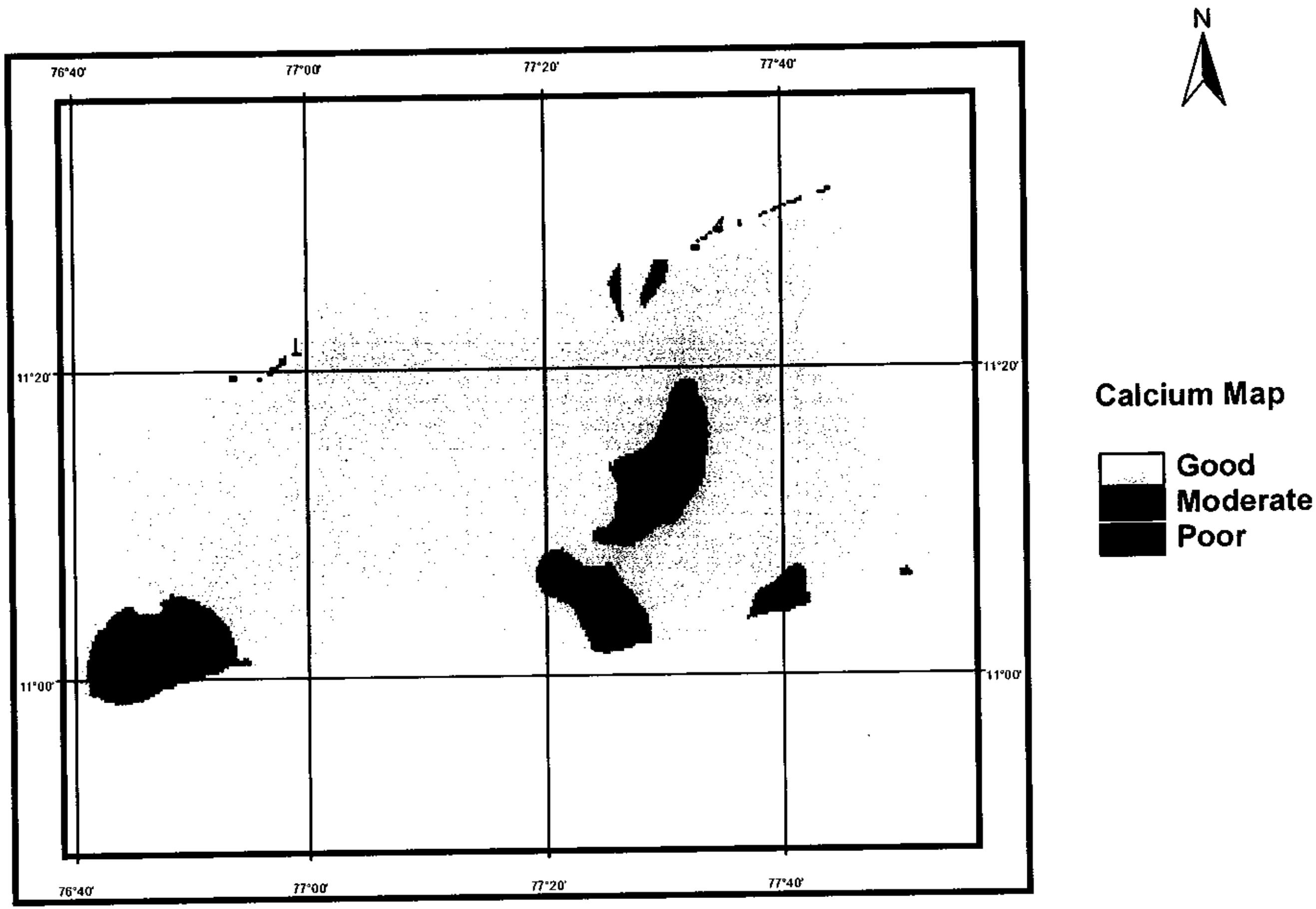


Figure 5.d Spatial variation map of Calcium for Avinashi-Athikadavu scheme zone

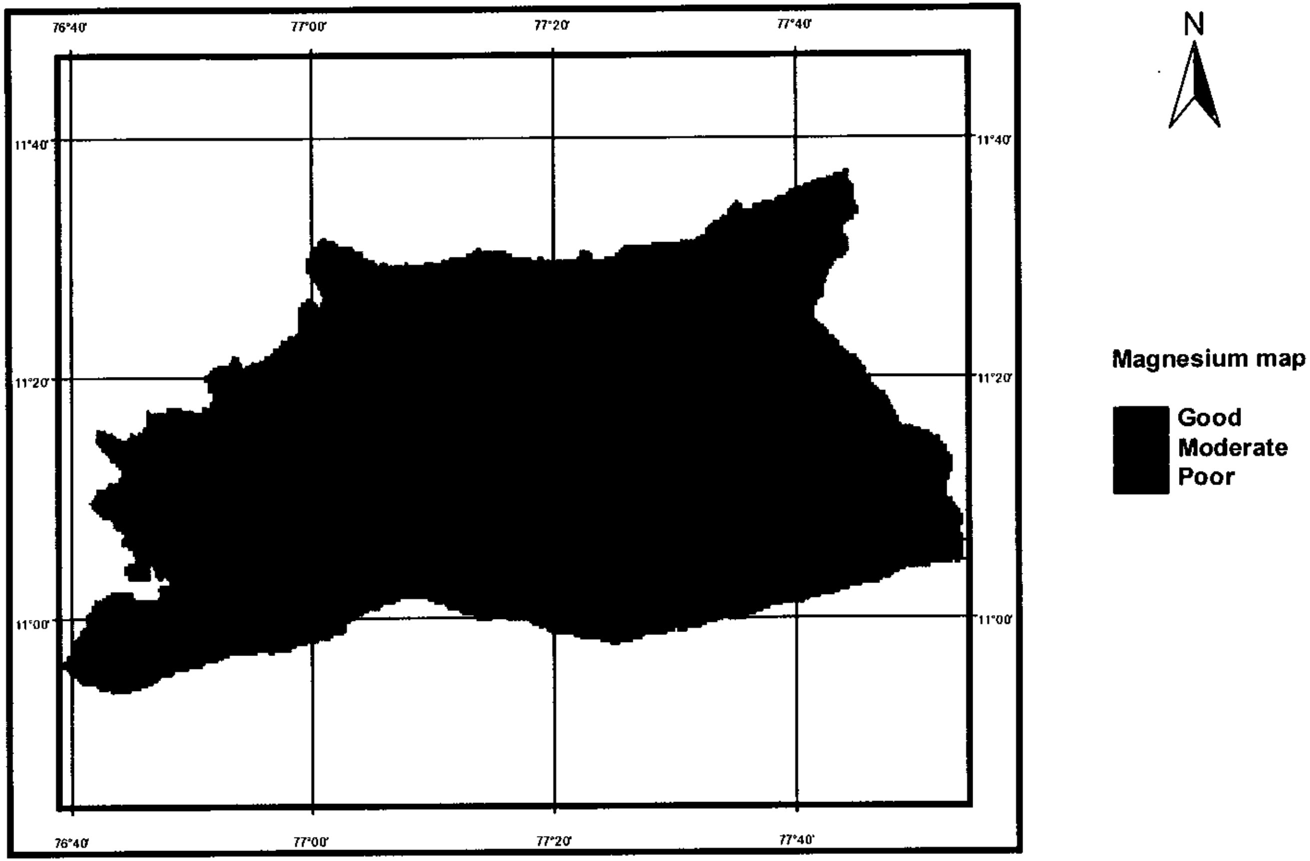


Figure 5.e Spatial variation map of Magnesium for Avinashi-Athikadavu scheme zone

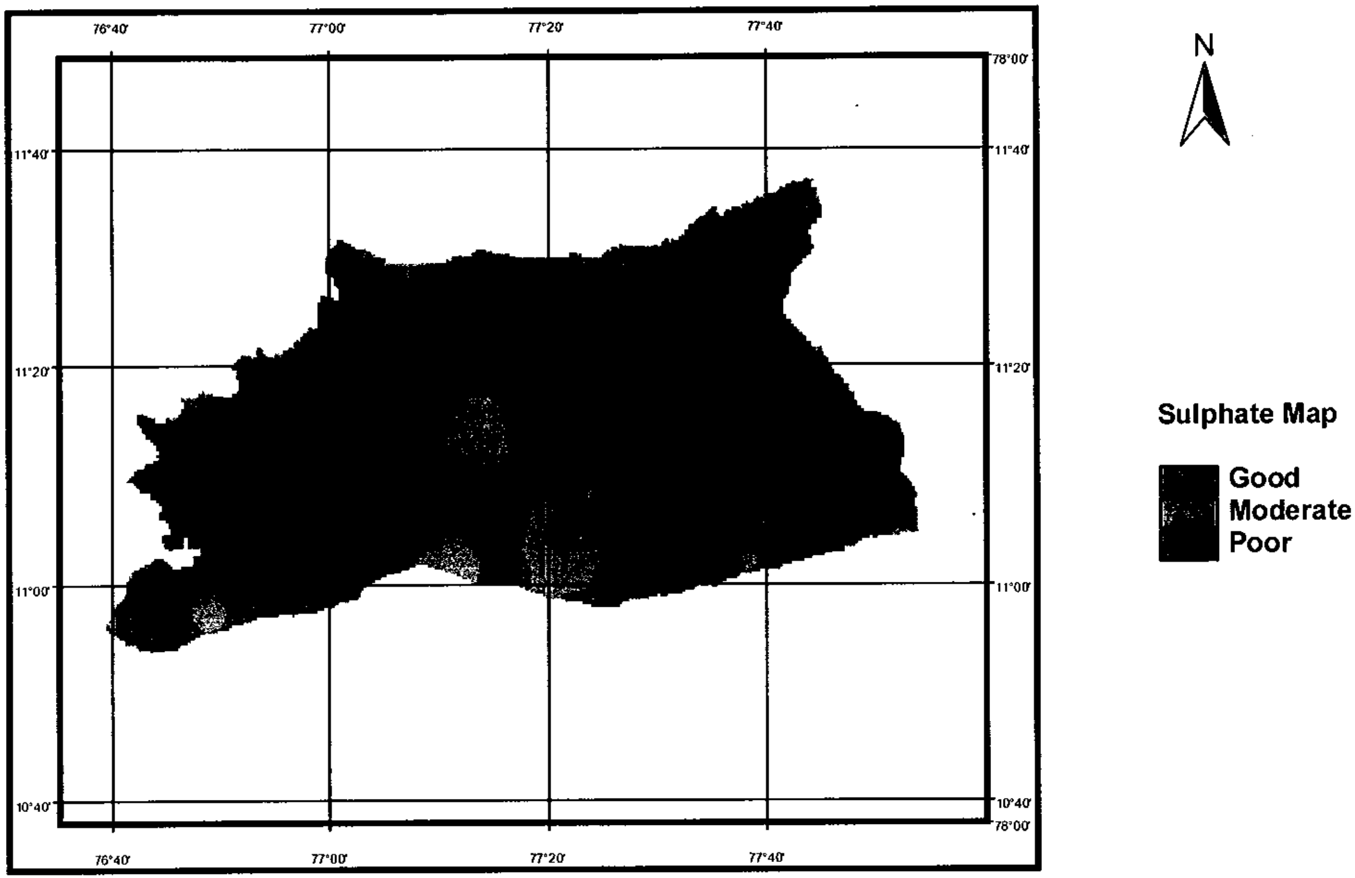


Figure 5.f Spatial variation map of Sulphate for Avinashi-Athikadavu scheme zone

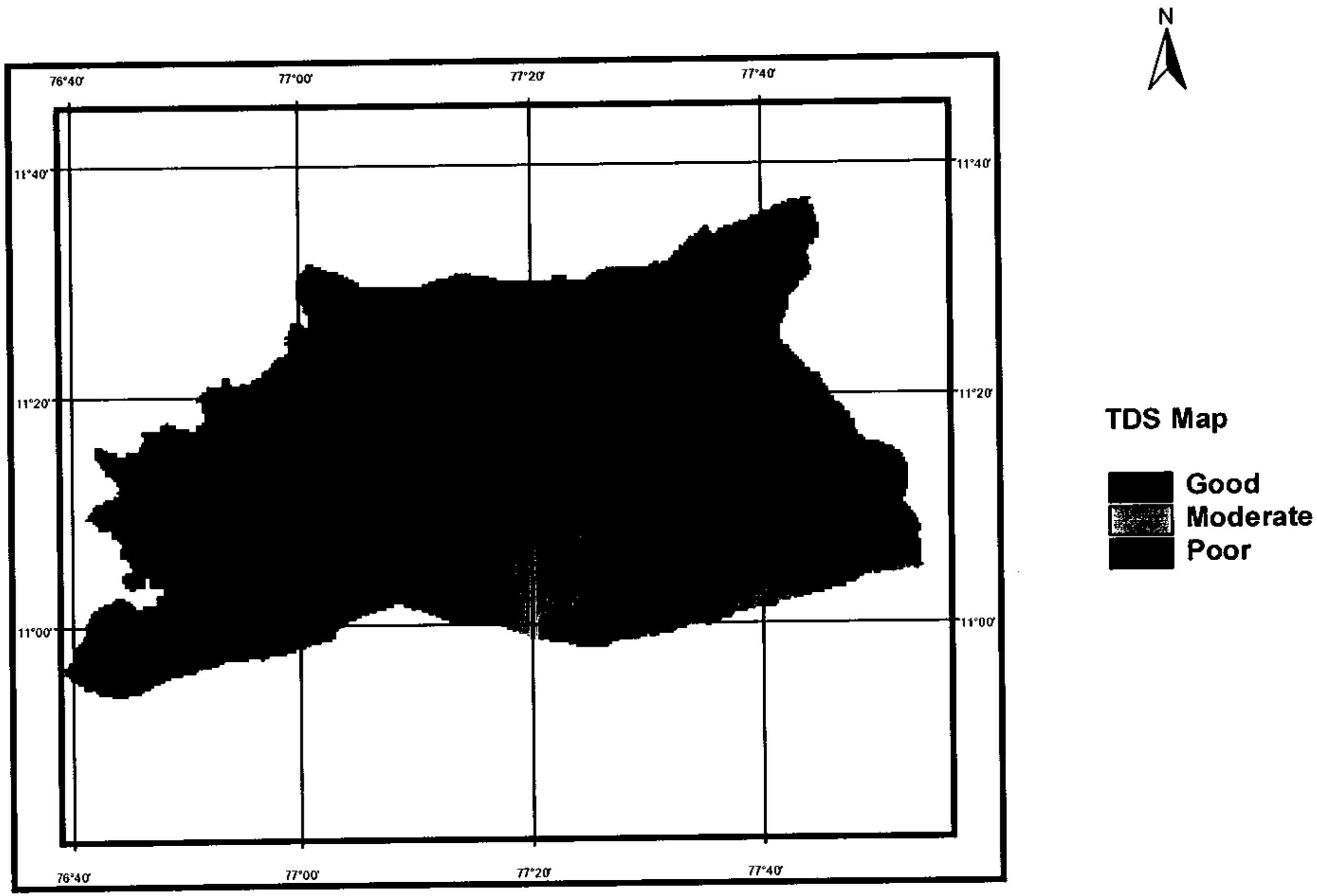


Figure 5.a Spatial variation map of TDS for Avinashi-Athikadavu scheme zone

RESULTS AND DISCUSSION

6. RESULTS AND DISCUSSION

6.1 GENERAL

The present study attempts to develop a GIS based groundwater model to assess the artificial recharge in the hard rock aquifer of sub-watershed. The groundwater recharge potential zones were delineated and sites suitable for implementing artificial recharge structures were identified in the sub-watershed using GIS. The effect of artificial recharge in the groundwater aquifer system was analyzed and presented in this chapter.

6.2 DELINEATION OF GROUNDWATER RECHARGE POTENTIAL ZONES

Groundwater recharge potential zones were delineated on the basis of geology, soil, and land use. The weighted index overlay analysis has been carried out using GIS. The decision rules have been derived to delineate the most suitable zones and to find out the exact sites for artificial recharge. Considering the hydrogeomorphic conditions of the area, weighted indexing has been adopted for the delineation of groundwater recharge potential zone. The justification for the choice of each parameter is discussed below.

6.2.1 Geology

The hornblende biotite gneiss has been given the highest priority as it supports high recharge when compared to charnockite.

6.2.2 Geomorphology

Buried pediment (shallow) has been assigned as higher weightage followed by pediment inselberg whereas the structural hills were assigned as less weightage.

6.2.3 Hydrological Soil Group

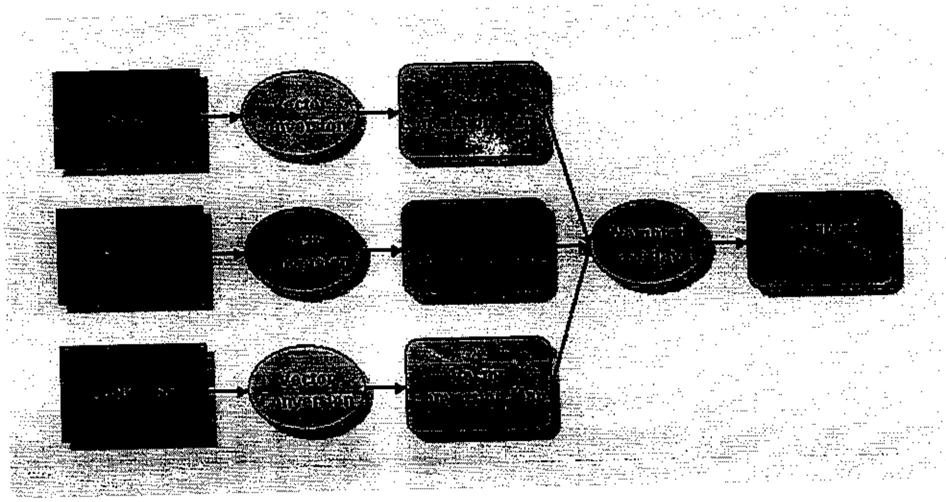
Hydrological soil group A has high infiltration capacity followed by B, C and D. The maximum area of sub-watershed was observed to be under hydrological soil group B followed by D. The hydrological soil group of A and B have to be given top priority for choosing artificial recharge structures. So, higher weightage is given to hydrological soil group B and lesser weightage was assigned to hydrological soil group D.

6.2.4 Land Use

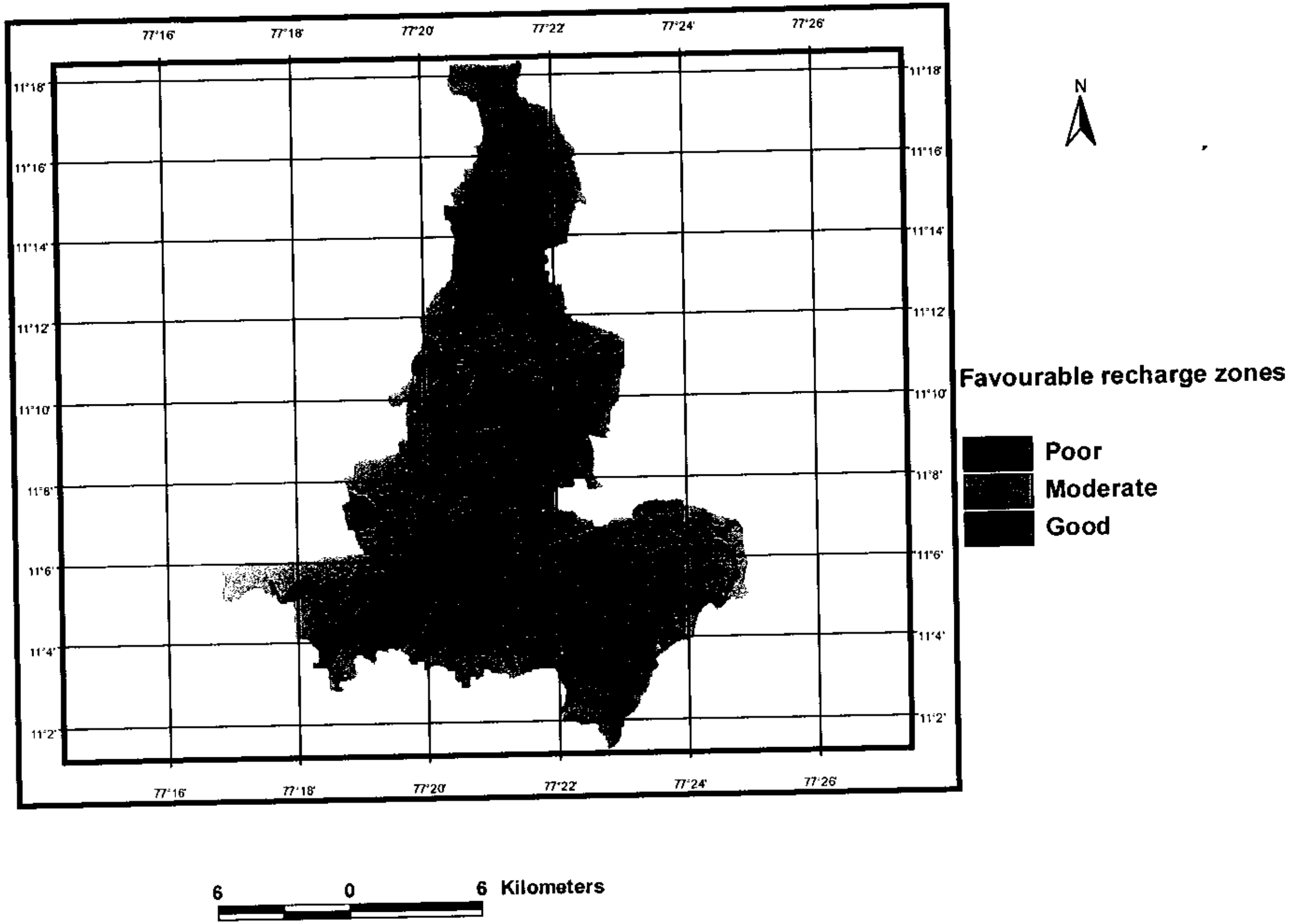
Among the various categories in the land use, top priority has to be given to plantation land and wet crop areas and lesser weightage was assigned to hills/rocky areas.

6.2.5 Integration of Thematic Layers

To demarcate the groundwater recharge zones all the thematic layers were integrated into a weighted overlay process. Weightage have been assigned to various classes of different themes like geology, geomorphology, soil, slope, runoff, lineaments and land use. Finally all these thematic maps have been converted into grid with related weightage supporting groundwater recharge potential and the entire model is run in Model builder tool. The groundwater recharge potential map of the study area has been generated after the model run.



The zones were delineated as good, moderate, poor and very poor. It is clear from the results that most part of the sub-watershed area comes under moderate recharge area and some parts in Northern and Southern areas show good recharge potential. The Western side of the sub-watershed shows poor recharge potential due to the presence of charnockite.



6.a Suitable locations of artificial recharge for Tiruppur district

6.3 SELECTION OF SUITABLE SITES FOR ARTIFICIAL RECHARGE

From the groundwater recharge potential zone map, the hydrogeomorphic parameters of good and moderate groundwater recharge zones were considered as favourable sites for the adoption of artificial recharge techniques. This would effectively exclude regions with very low groundwater recharge potential where artificial recharge techniques cannot be employed. The drainage pattern map is superimposed over the groundwater recharge potential map and used to identify favourable locations for implementing artificial recharge structures in the study area. Finally, suitable recharge structures such as percolation ponds, check dams, recharge wells, recharge pits, recharge shafts and dug wells were recommended. Percolation ponds and check dams were adopted based on the drainage morphology in the areas demarcated as favourable for artificial recharge.

Percolation ponds, check dams, recharge wells, recharge pits, recharge shafts and dug wells provide a good measure of artificial recharge in hard rock terrains by collecting surface runoff and increasing the infiltration capacity. The selection of these structures depends on the terrain condition with good recharge potential of groundwater. The major artificial recharge structures such as percolation ponds and check dams. The recharge wells, recharge pits, recharge shafts and dug wells are the minor artificial recharge structures and they can be adopted with the major artificial recharge structures. The brief description of these recharge structures recommended in the study area is given below.

6.3.1 Percolation Ponds

These structures are recommended in the favourable recharge-storage zones to ensure more recharge especially in the non-monsoon months. Similar types of percolation ponds are suggested in the study area wherever the highly favourable zones with suitable terrain conditions exist. Percolation ponds can perform efficient by only in areas where drainage pattern with catchment characteristics or closed watershed conditions are available within the favourable area. The drainage pattern map, which is superimposed over the artificial-recharge zonation map, enables the identification of sites that satisfy the above criteria for percolation and ponding.

In the present study, percolation ponds are recommended in the good to moderate groundwater potential zones with suitable terrain conditions. The areas with less than 5% of slope are selected as suitable sites for percolation ponds. These structures are located mostly near the 5^{th} and 6^{th} order streams as they supply water continuously throughout the year, which is a preferable criterion for the efficient performance of the ponds. The size of basin may depend upon the topography of area, in flatter area will have large basin.

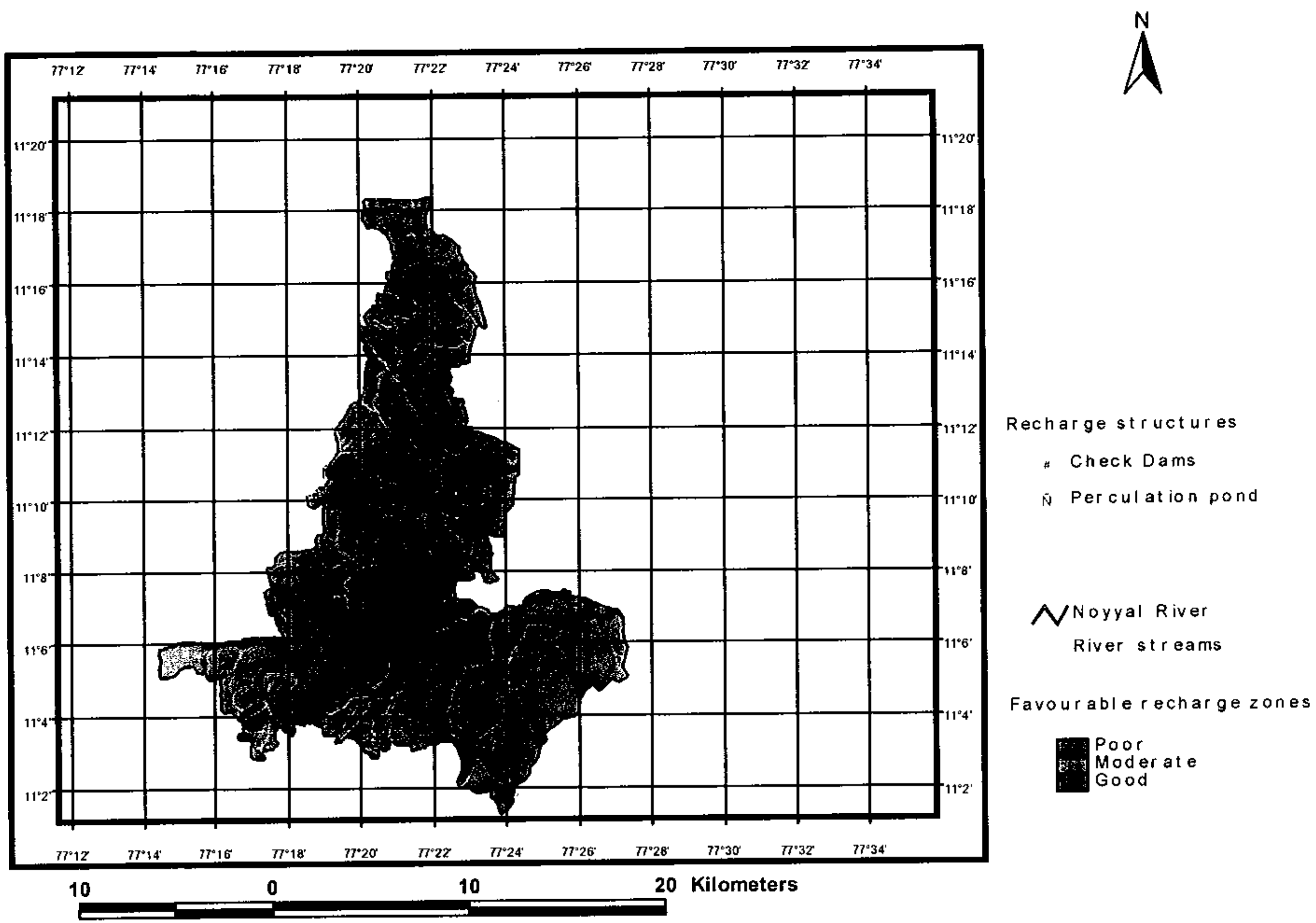
The most effective depth of water in basin is 1.25 m because lesser or greater depths resulted in reduced rate of infiltration.

Recharge through percolation ponds will be efficient because of adequate runoff and the presence of favorable areas present in the study area for recharging groundwater. Overall, sixteen sites have been identified in the sub-watershed. These structures play a major role in augmenting the yield of wells.

6.3.2 Check Dams

The check dams are the structures built across lower order streams in order to prevent runoff and detain the water to enhance infiltration into the subsurface. Check dams are recommended at nineteen locations across the 2^{nd} and 3^{rd} order streams in the good to moderate recharge potential zones of the sub-watershed with less than 5% slope.

The site selected for check dam should have sufficient thickness of permeable bed or weathered formation to facilitate recharge of stored water



6.b Suitable locations of artificial recharge structures for Tiruppur District within short span of time. The water stored in these structures is mostly confined to stream course and height is normally less than 2 m. To harness maximum runoff, a series of such check dam may be constructed. These check dams would prevent the water from flowing down to join the higher order streams and instead permit the water to spread out around the lower order streams and recharge the aquifer.

6.3.3 Recharge Pits and Shafts

In the area where impervious layer is encountered at shallow depth recharge pits and shafts are suitable structures for artificial recharge. These structures are cost effective to recharge the aquifer directly. The diameter of shaft should normally be more than 2 m to accommodate more water.

Silt free source water can be put into shaft and pit directly through pipes, if this pipe is kept above water table there are chances of choking of the aquifer by air bubble with water therefore it is always advisable to lower the injection pipe below the water level.

On other hand in the areas where source water is having silt the recharge shaft and pit should be filled with boulder, coarse sand from bottom to have inverted filter or the source water should be passed through a separate filter chamber before it enters the recharge shaft and pit. The advantage of recharge shafts and pits structure is that they do not require large area of land like percolation tank and other spreading method and there are practically no losses of water in form of soil moisture and evaporation like other methods of spreading.

6.4 ARTIFICIAL GROUND WATER RECHARGE

Average annual water resources in our river basins are estimated as 1,869 billion cubic metres (BCM) of which utilizable resources are of the order of 1,086 BCM. Out of this, 690 BCM is available as surface water and the remaining 396 BCM as ground water. The source of all this water is rain or snow. The huge ground water storage of 396 BCM is the result of rain and snowmelt water percolating through various layers of soil and rocks. However, the amount of percolation varies greatly from region to region and within the same region from place to place depending upon the amount and pattern of rainfall (i.e. number and duration of rainy days, rainfall amount and intensity), characteristics of soils and rocks (i.e. porosity, cracks and loose joints in rocks etc.), the nature of terrain (i.e. hills, plateaus, plains, valleys etc.), and other climatic factors like temperature and humidity. As a result, availability of water from sub-surface storages varies considerably from place to place.

In most low rainfall areas of the country the availability of utilizable surface water is so low that people have to depend largely on ground water for agriculture and domestic use. Excessive ground water pumping in these areas, especially in some of the 91 drought prone districts in 13 states, has resulted in alarming lowering of the ground water levels. The problem has been further compounded due to large-scale urbanization and growth of mega cities, which has drastically reduced open lands for natural recharge. In hard rock areas there are large variations in ground water availability even from village to village.

In order to improve the ground water situation it is necessary to artificially recharge the depleted ground water aquifers. The available techniques are easy, cost-effective and sustainable in the long term. Many of these can be adopted by the individuals and village communities with locally available materials and manpower.

6.5 ADVANTAGES OF ARTIFICIAL RECHARGE

Main advantages of artificially recharging the ground water aquifers are,

- Structures required are small and cost-effective
- Enhance the dependable yield of wells and hand pumps
- Negligible losses as compared to losses in surface storages
- Improved water quality due to dilution of harmful chemicals/ salts
- No adverse effects like inundation of large surface areas and loss of crops
- No displacement of local population
- Reduction in cost of energy for lifting water especially where rise in ground water level is substantial
- Utilizes the surplus surface runoff which otherwise drains off

6.6 IDENTIFICATION OF AREAS FOR RECHARGE

The first step in planning a recharge scheme is to demarcate the area of recharge. Such an area should, as far as possible, be a micro-watershed or a mini-watershed. However, localized schemes can also be taken up for the benefit of a single hamlet or a village. In either case the demarcation of area should be based on the following broad criteria:

- Where ground water levels are declining due to over-exploitation
- Where substantial part of the aquifer has already been desaturated i.e. regeneration of water in wells and hand pumps is slow after some water has been drawn
- Where availability of water from wells and hand pumps is inadequate during the lean months

- Where ground water quality is poor and there is no alternative source of water

6.7 SOURCES OF WATER FOR RECHARGE

Before undertaking a recharge scheme, it is important to first assess the availability of adequate water for recharge. Following are the main sources, which need to be identified and assessed for adequacy:

- Precipitation (rainfall) over the demarcated area
- Large roof areas from where rainwater can be collected and diverted for recharge
- Canals from large reservoirs from which water can be made available for recharge
- Natural streams from which surplus water can be diverted for recharge, without isolating the rights of other users
- Properly treated municipal and industrial wastewaters. This water should be used only after ascertaining its quality

"In situ" precipitation is available at every location but may or may not be adequate for the recharge purposes. In such cases water from other sources may be transmitted to the recharge site.

Assessment of the available sources of water would require consideration of the following factors:

- Available quantity of water
- Time for which the water would be available
- Quality of water and the pretreatment required

- Conveyance system required to bring the water to the recharge site

6.8 METHODS OF ARTIFICIAL RECHARGE

These can be broadly classified as:

- Spreading Method
    - Spreading within channel
    - Spreading stream water through a network of ditches and furrows
    - Ponding over large area
        (a) Along stream channel viz. Check Dams/ Nala Bunds
        (b) Vast open terrain of a drainage basin viz. Percolation Tanks
        (c) Modification of village tanks as recharge structures.
- Recharge Shafts
    - Vertical Shafts
    - Lateral Shafts
- Injection Wells
- Induced Recharge
- Improved Land and Watershed Management
    - Contour Bunding
    - Contour Trenching
    - Bench Terracing
    - Gully Plugging

CONCLUSIONS

7. CONCLUSION

The following conclusions were attained from the present study

- The hydrological soil group and land use pattern map have been integrated to derive the maximum area of watershed was observed.

- Seven types of land use pattern were identified in the sub-watershed such as agricultural cropland, fallow/harvested land, cultivable lands, water bodies, built up lands, salt affected area and hills/rocks.

- Groundwater recharge potential zones were delineated on the basis of geomorphology, soil, land use and drainage map.

- Artificial recharge structures such as percolation ponds, check dams, were recommended. They were located based on the drainage morphology in the areas demarcated as favourable for artificial recharge.

- The water quality for areas of avinashi - athikadavu scheme was done and it was found that quality of water is most affected in Tiruppur zone.

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8. BIBLIOGRAPHY

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