CHAPTER IV

REMOTE SENSING

4.1 Introduction

Ground water occurs in good quantities all over the globe and has become an alternative source where the surface water is deficient. As the population has been growing up relatively the needs have been escalated and the ground water becomes indispensable. Groundwater in nature is free from pathogenic organism and hence exists in purified state. This is an essential criteria for the development and sustenance of life on the earth. The main problem is to identify and delineate the favourable water bearing formations especially in hard rock terrain. It is felt that the conventional methods employing the insitu devices have become expensive, laborious and time consuming. Considerable savings of time as well cost can be effected if only we know ‘where to begin the detailed exploration programme’.

Realising the demand of ground water for man’s progress, careful and effective modern techniques were developed. One of such techniques is Remote Sensing, which has become an essential tool for geohydrologist, involved in the ground water investigations.

Remote Sensing is the observation of earth’s surface by a device separated from it by some distance. It is a conglomeration of
variety of techniques that have been developed for the acquisition and analysis of information about the earth. This ‘information’ is typically in the form of electromagnetic radiation that has been reflected, emitted, transmitted or absorbed from the earth’s surface. Since no single instrument is capable of detecting all this radiation, a number of different surveys are developed. Each sensor acquires energy measurements in a discrete portion of the electromagnetic spectrum. The sensor so operating in the region of 0.4 to 1.1 micro metre is found suitable for water resources studies. The scientists feel that the data obtained from this spectrum is invaluable for exploration, conservation and management of natural resources like ground water etc. multispectral remote sensing data have shown tremendous potential for application in ground water and other geo-environmental studies. It may said to have two fold purpose:

- To allow viewing of the ground surface in a different perspective, on a different scale or on a different spectral vision and
- To reduce the amount of fieldwork involved for covering the entire study area.

4.2 Data products used

Aerial photographs

Job No: 1067 A

Strip No: 22 Photo No: 10 – 14
Strip No: 24 Photo No: 8 – 11
In this imagery, varied plant types are seen in different hues and mountain ranges are seen in dark terrain. Water bodies are seen in various shades of blue, darker the shade closer the waterbody. Many rivers are also blue in colour. The vegetation in many parts is forest, grassland, cropland or plants are seen in different shades of reflectance areas like salt, snow and affected areas are seen in white color. The urban areas are in grey to blue colour.
Season: Feb 1980
Scale: 1:56,000

Satellite imagery

Indian remote sensing satellite (IRS) IB LISS II FCC
Geocoded 58 I/4 & 8, Scale: 1:50,000
Landsat imagery FCC, Scale: 1:250,000

Government of India toposheets
58 I/4 & 8, scale: 1:50,000

4.3 Methodology

Indian remote Sensing satellite (IRS) IB LISS II data (Geocoded) acquired in the form of False Colour Composite (FCC) generated from bands 2,3 & 4 on 1:50,000 scale is interpreted using visual interpretation technique. Aerial photographs in 1:56,000 are also used under stereoscope for synoptic view of the watershed for delineation of clear watershed boundary, structure, land use and land cover pattern, litho-contact etc. The scale variations are corrected by using Optical pantograph. Further local knowledge of the area and the available data such as Geology of the area from Geological Survey of India (GSI) are take into consideration at the time of interpretation. The interpreted features and units are transferred to the base map prepared from the Survey of India topographic maps on 1:50,000 scale. Field checks are carried out at selected locations for verifying the doubtful units and thematic maps like Geology, Geomorphology, Structure, Drainage, Soil, Land use etc. are finalised. Lineament and
Drainage density maps are derived based on lineament fabrics and drainage network.

4.3.1 Interpretation of remote sensing data

Aerial and satellite remote sensing has made it easy to survey not only a range of our natural resources covering large area more economically but also monitor the change that take place (Narayanan L.R.A, 1988). Qualitative and quantitative interpretation of morphic features and structural feature such as lineament fabric provides useful information for identification of suitable area for ground water exploration and augmentation. Drainage network analysis provides information about the run off water, infiltration capacity, perviousness and texture of material etc., and lineament fabric analysis is the indicators of joints, fractures, faults, shear zones, litho-contacts etc. (Pauline waters, 1988).

Image interpretation is done in two ways. i. Visual interpretation, ii. Digital interpretation. Visual interpretation is done with naked eye and some times using the stereoscopes and magnifiers. Digital interpretation is involving the computers and using raw or processed digital data obtained from the satellite. For the study area, only visual interpretation of satellite imagery and aerial photographs is carried out based on the photo recognition elements like tone, texture, shape, size pattern etc. and geotechnical elements like land forms, drainage pattern, soil, land use and land cover as well as vegetation cover and erosion etc. Associated features and
convergence of evidence are applied along with the above elements for prediction of the terrain features.

4.4 Geomorphology

Geomorphology deals with the study of landforms and landscapes, including their description, type and genesis. Landforms are the end product of resulting from the interactions of the natural surface agencies and type of rock. It depends upon three main factors: (a) climatic setting including its variation in the past, (b) underlying bedrock (rock type and structure), (c) time span involved. This intern influences the image/photo characters (Figure IV.1). Synoptic coverage and stereoscopic ability of remote sensing permits evaluation of land forms, relief, slope etc. valuable review contributions on geomorphological applications of remote sensing, particularly aerial photography have been made by Tator (1960), Miller and Miller (1961) and Versatappan (1983).

The following terrain parameters are predicted by the visual interpretation of satellite imagery and aerial photographs.

Landforms

Structure

Drainage

Land use & Land cover etc.,
4.5 Land forms

It is well established that different geomorphic processes are responsible for the present day landforms of the terrain and their irregular outline. The rate and intensity of depositional and denudational processes never be uniform and steady causing uneven outcropping limits. The various geomorphic units are identified by the careful analysis of various outcrop patterns and characteristics.
landforms of this area. The following are the geomorphic units recognized in this area based on the above analysis (Figure IV.2).

A. **Fluvial Forms**
   
i.) Bazada plain.

B. **Denudational Forms.**
   
i.) Deep Buried Pediment
   
ii.) Shallow Buried pediment
   
iii.) Pediment
   
iv.) Structural hills
   
v.) Residual hills

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4.5.1 **Bazada zone**

Characteristic of this unit identification is series of coalescing fans and sub-parallel drainage. The cone shaped fans are resulted due to the continuous gradual supply of debris and coarse material brought down by streams from exposed high relief terrain. Bazada zone is more prevalent in the northern portion of the study area at the foot of the upland hills with moderate slope. Coarse nature of material and internal drainage observed in this zone suggests as high infiltration zone.
ERUMAIPATTI WATERSHED

GEOMORPHOLOGY

see on aerial photo & satellite imagery IRS IB LISS II)

0.9 0 0.9 Kilometers

- Structural hill
- Bazzada zone
- Deep buried pediment
- Shallow buried pediment
- Pediment
- Residual hill
4.5.2 Deep buried pediment

This unit constitutes where the weathered zone is more than 10 m. It comprises medium to coarse grained material. In the study area this unit is classified based on the high land use, dark to medium tone due to moisture content. 30% of the area is covered with deep buried pediment. Correlation of weathered zone and deep buried pediment indicates that it extends even above 30 metres depth in select locations (Plate-5).

4.5.3 Shallow buried pediment

This unit differs from deep buried pediment due to the variation of depth in weathered zone, which ranges from 5-10 metres. It is interpreted from aerial photographs and satellite imageries based on the moderate land use and medium gray tone. Dry crops like cholam is cultivated (Plate-6).

4.5.4 Pediment

McGee (1897), Both Paige (1912) and Peel (1960) have described that pediment zone is a clear bed rock surface without any cultural development. The soils cover mostly absent or with thin veneer of soil cover. It is distinguished in the aerial photographs and satellite imageries by light gray tone and gray structure. Land use is very sparse. In the thin soil cover area sheet erosion is prominent (Plate-3).
Plate 5. Deep buried pediment with intensive cultivation.

Plate 6. Shallow buried pediment with dry crops
4.5.5 Structural hill

Prominent structural hill is mapped in the northern part of the area i.e., "Kolli hills" marked by high relief, steep dipping foliation and "hogbacks" feature and sub parallel drainage pattern. Plate-7 & 8 shows the part of kolli hills in the northern and western part with structure controlled streams.

4.5.6 Residual hill

These are isolated resistant rocky areas on the basement of weathering residue of the parent rock. They are generally asymmetric top, free face debris slopes and wening slopes undergoing tremendous amount of denudation since long time.(Meyeriak 1970). The residual hills are mapped in the southern and southwestern part of the area.

4.6 Structure

The crystalline complex of Archean age has undergone varied degree of metamorphism leading to the secondary structures like joints, fractures and fissures. The area exhibits subdued to plain topography except in the Kolli hills in the northern part of the area. Hence depicting any major structure is found difficult due to the considerable thickness of soil cover. The upland hill is structurally complicated with minor folds. The upland area is mainly composed of charnockite intruded with discontinuous basic dykes.

Due to varied degree of metamorphism over this area regional trend is not the same through out the area. The trend of the
Plate 7. Part of kolli hills with structure controlled drainage and piedmont zone

Plate 8. Structural hill and piedmont zone in the NW.
formation varies from N10°E to N60°E with varied dip ranges from 40-70°SW.

4.6.1 Lineaments

Lineaments, which are supposed to be indicators of joints, fractures, fault, shear zones, litho contacts have been picked up easily in the satellite imagery and aerial photographs of 1:50,000 scale. A lineament is a linear feature annotated as a two dimensional document by an observer who believes it to represent natural feature of the landscape (Gay, 1972). William H. Hobbs (1904, 1912) recognized the existence and significance of linear geomorphic features that are surface expression zones of weakness or structural displacements in the crust of earth. Location of the well sites may be slightly off the lineament investigations due to the presence of fine materials reducing permeability in the center of inferred fracture zones (Persander et al, 1997). Well siting should not be solely on lineament coordinates from the computer screen, but in conjunction with a detailed investigation in the field.

About 67 lineaments of varying sizes are mapped from the IRS 1B LISS FCC data and aerial photographs. The length of the lineament on ground ranges from 0.5 to 5.5Kms and total length of the lineament in the watershed is 116.1Km (Figure IV.3). Based on the orientation and length, lineament frequency azimuth diagram is prepared (Figure IV.4). It shows that two major sets of lineaments, two sets each in NE–SW and NW–SE direction. The other sets of
ERUMAIPATTI WATERSHED

STRUCTURE
(Based on aerial photo & IRS IB LISS II)

0.9 0 0.9 Kilometers

Lineament
Shear zone
Erumalpettai watershed
LINEAMENT DISTRIBUTION
lineaments are deviated from the main set. The main set of lineaments may be regional lineaments and the other sets may be boundary lineaments (Moodey & Hill, 1956).

Drainage features in the area are more difficult to interpret. Straight portions of dry streambeds have, in general been interpreted as indications of fracture zones. A few of interpreted lineaments in the watershed area is found to correspond to litho-contacts. In areas of deep weathering and regolith cover and areas with dark vertisols, lineaments are much less distinct and the interpretation accuracy more uncertain.

Fracture zones related to brittle deformation are normally separated into tensional zones and shear zones. Tension zones have high storage capacity, while shear zones can range from tight to highly permeable, depending upon their stage of development (Gustafsson, 1994). Lineament interpretation has, in some projects formed the basis for a delineation of the original stress regime, which subsequently has has been used to develop a "hydro tectonic" model, from which promising fracture zones for ground water development have been identified, (VIAK 1984). Lineaments in a terrain may be very variable in their hydrogeological character, they may represent lithological contacts, dykes, or ductile or brittle deformation zones (Banks et.al. 1994).
4.6.2 Lineament density

Lineament density map is derived by dividing the area into small grids of 1cm x 1cm in the 1:50,000 scale and assigning the total length of the lineaments, which falls in each grid, divided by grid area (Figure IV.5). The density contours are prepared by using SURFER16 software. The axis of density concentration has been drawn and the longer axis of the lineament density grids has been identified. The axis of the density concentration can be regarded as major trends of lineaments (Figure IV.5a) which have been derived from the graphical treatment of the actually mapped lineament from remotely sensed database (Verma 1993). Natesan, et al. (1998) integrated the lineament density and drainage density for identification of ground water potential zones in Erumaipatti watershed of Cauvery Basin.

The field's checks also confirm the prominent ground signatures of the derived lineaments. 8 out of 16 axis of the density concentration are in the NNW-SSW direction and the remaining is in the NE-SW direction. The major axis, which is in the NE-SW direction also, confirms the presence of shear zone identified by GSI in the watershed area. The lineament density is high in the two super groups of formation i.e. Charnockite group and Sathiyamangalam group, which separates the upland, run off zone and pediplain area. It is generally recognized that lineament or 'fracture trace' analysis used in conjunction with ground water investigation of fractured bedrock
ERUMAIAPPATTI WATERSHED
LINEAMENT SETS

0.9 0 0.9 Kilometers

Legend:
- Low
- Medium
- High

Map showing lineament sets with different intensity levels.
aquifers, are not credible without field verification (Stephen et al. 1994).

4.7 Drainage

Drainage pattern is the spatial arrangement of streams and is in general is the very characteristic of the terrain. The drainage networks possess a geometric regularity of different types, which reveal the characteristic of the geological terrain. Howard (1967) has summarised the geological significance of various drainage patterns (Table IV.1). The surface drainage pattern characteristics of various basins and sub-basins have been studied using conventional methods in earlier studies (Horton, 1965; Strahler, 1969). Such studies lack time effectiveness of data for a large drainage network over a whole basin.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Geological significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dentritic</td>
<td>Irregular branching of streams, resembling a tree</td>
<td>Homogenous material and crystalline rocks: gentle regional slope</td>
</tr>
<tr>
<td>Sub dentritic</td>
<td>Slightly elongated pattern</td>
<td>Minor structural control</td>
</tr>
<tr>
<td>Pinnate</td>
<td>High drainage density pattern; feather like</td>
<td>Fine grained materials</td>
</tr>
<tr>
<td>Rectangular</td>
<td>Streams having right-angled bands</td>
<td>Jointed/faulted rocks</td>
</tr>
<tr>
<td>Parallel</td>
<td>Streams running parallel to each other</td>
<td>Steep slopes; also in areas of parallel elongate land forms</td>
</tr>
<tr>
<td>Trellis</td>
<td>Main stream running</td>
<td>Dipping or folded</td>
</tr>
<tr>
<td></td>
<td>parallel and tributaries joining the main stream nearly at right angles</td>
<td>low grade meta-sedimentary rocks; areas of parallel fractures</td>
</tr>
<tr>
<td>------------------</td>
<td>------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Radial</td>
<td>Streams originating from the central point</td>
<td>Domes, intrusions, residual erosion</td>
</tr>
<tr>
<td>Centripetal</td>
<td>Streams converging to central point</td>
<td>Depression, basin, sink holes</td>
</tr>
<tr>
<td>Annular</td>
<td>Ring like pattern</td>
<td>Structural domes</td>
</tr>
</tbody>
</table>

Table: IV.1 Drainage patterns and their geological significance

Remote sensing data in the form of aerial photos and satellite images provide a unique data set for studying the drainage pattern, drainage density etc. (Agarwal, 1998). The information about drainage characteristics is essential for the determination of linear and aerial aspects of drainage. Hence drainage network of the watershed area is mapped from the aerial photographs and toposheets of 1:50,000 scale and numbered adopting Strahler’s method. The drainage originates from Kolli hills in the north and flows towards south and southwest and joins with the river Karaipottanar. The watershed is having V orders of drainage and the main river forms the Vth order. Total length of the streams measured by using Map measurer is 192Km and number of stream covers the watershed is 205 (Figure IV.6).

4.7.1 Drainage density
The watershed area is divided into small grids of 1cm x 1cm in the 1:50,000 scale and length of the drainage in each of the grid is
ERUMAIAPPATTI WATERSHED
DRAINAGE NETWORK

0.9 0 0.9 Kilometers
measured and Drainage density for each grid is calculated. The Drainage density value coordinates are put into the computer by using SURFER16 software and Drainage density contours are plotted (Figure IV.7). The Drainage density network of a watershed play a vital role in revealing the basic factors like the lithology, landform soil condition, climate, rainfall and run off. Drainage density is high in the run off zones of upland hills in the northern part of the area and in the South and Southeast part of the watershed. In the pediplain area Drainage density ranges from moderate to low due to the variation in the infiltration capacity, perviousness of the soil and run off rates.

4.8 Land use & Land cover

Land use is referred to as “Man’s activities and the various use which are carried out on land”. Land cover is referred to “Natural vegetation, Water bodies, rock/soil, artificial cover and other noticed on the land” (NRSA 1989). Since both land use and Land cover are closely related and are not mutually exclusive they are inter changeable as the former is inferred based on the land cover and on the contextual evidence.(Gautam,1999)

By visual interpretation of the remote sensing data products the Land use and Land cover map of the area is prepared (Figure IV.8). Geographical area of each land use unit is calculated and are shown below
<table>
<thead>
<tr>
<th>S.No</th>
<th>Land use &amp; Land cover unit</th>
<th>Area in km²</th>
<th>Percentage of area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Settlement</td>
<td>3.755</td>
<td>3.09</td>
</tr>
<tr>
<td>2</td>
<td>Dry crop area</td>
<td>4.889</td>
<td>34.50</td>
</tr>
<tr>
<td>3</td>
<td>Wet crop area</td>
<td>36.493</td>
<td>30.00</td>
</tr>
<tr>
<td>4</td>
<td>Degraded forest</td>
<td>25.709</td>
<td>21.20</td>
</tr>
<tr>
<td>5</td>
<td>Barren land</td>
<td>5.407</td>
<td>4.50</td>
</tr>
<tr>
<td>6</td>
<td>Rock out crop</td>
<td>4.132</td>
<td>3.40</td>
</tr>
<tr>
<td>7</td>
<td>Problem soil</td>
<td>0.826</td>
<td>0.70</td>
</tr>
<tr>
<td>8</td>
<td>Water body</td>
<td>3.289</td>
<td>2.70</td>
</tr>
</tbody>
</table>

**Total** 121.50

4.8.1 Soil

Soil texture is important because it is largely determines the retention and infiltration capacity. Sand may get drained too rapidly, whereas in a clayey soil the individual pore spaces being too small, the infiltration capacity is low. Soil texture and colour are identified as model parameters and based on the same the watershed is classified in four groups of soil. The criteria for hydrologic soil group as below
<table>
<thead>
<tr>
<th>Character</th>
<th>Hydrologic soil groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Infiltration rate</td>
<td>High</td>
</tr>
<tr>
<td>Texture</td>
<td>Sand/gravel</td>
</tr>
<tr>
<td>Depth</td>
<td>Deep</td>
</tr>
<tr>
<td>Drainage</td>
<td>Well to excess</td>
</tr>
<tr>
<td>Water transmission</td>
<td>High</td>
</tr>
<tr>
<td>Remarks</td>
<td>Low run-off</td>
</tr>
</tbody>
</table>

Visual interpretation of the IRS IB FCC satellite imagery based on colour, tone and texture soil mapping of the watershed area has been carried out except in the run-off zone (Hill area). The soil map indicates that all the four hydrological soil groups are spread over the watershed with the predominance of mainly C & D groups (Figure IV:9). Plate-4 shows the distribution of red soil in the southern part of the watershed. Geographical aerial extent is calculated and the details of the soil group coverage is as below.
Plate 3. Pediment with black soil cover in the eastern side

Plate 4. Red soil in the southern part of the watershed
<table>
<thead>
<tr>
<th>S.No</th>
<th>Soil group</th>
<th>Area in km²</th>
<th>Percentage of area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>6.72</td>
<td>5.53</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>1.54</td>
<td>1.27</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>44.81</td>
<td>36.88</td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>39.63</td>
<td>32.62</td>
</tr>
<tr>
<td>5</td>
<td>Run-off zone</td>
<td>28.80</td>
<td>23.70</td>
</tr>
</tbody>
</table>

4.9 Slope analysis

Slope and altitude are important parameters from utilisation point of view. Slope analysis of a terrain is vital one for land irrigability and land capability assessment. Altitude has the bearing on the vegetation type and conditions. As per the guidelines of AIS & LUS and Soil survey manual IARI 1971 the slope map prepared on 1:50,000 scale is categorized as follows.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Slope category</th>
<th>Slope %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nearly level</td>
<td>0 - 1</td>
</tr>
<tr>
<td>2</td>
<td>Very gentle slope</td>
<td>1 - 3</td>
</tr>
<tr>
<td>3</td>
<td>Gentle slope</td>
<td>3 - 5</td>
</tr>
</tbody>
</table>
Survey of India topographic maps in 1:50,000 scale is used for deriving the information on slopes. The vertical drop is estimated/measured from the contour interval and the horizontal distance in between the contours is measured from the maps by multiplying the map distance and scale factor. Slope is expressed in percentage of vertical drop over horizontal distance. Closely space contours on the map have higher percentage slope as compared to the sparse contours in the same space.

For a contour spacing of 2.0 cm in 1:50,000 scale of 20-m contour interval the slope is

\[
= \frac{(20 \times 100)}{(2 \times 50,000)/100} = 2\%
\]

Assessing the contour spacing for all the area of map either by random or on select grid size slope of the entire watershed is calculated. With the X and Y coordinate for each location the slope value is added and smooth contours are prepared by using Krigging method in SURFER. The zonation of the contour is done as defined in the AIS and LUS.
In the study area very steep slope of more than 35% is in the upland area of kolli hills and 10 – 35 % falls in the foot of the Kolli hills and on the top of the hill where there is moderately steep slope is noticed. Moderate slope of 5-10 % is in the upside of the bazada zone and in the residual hills in the southern part of the watershed. 3 – 5 % gentle slope falls in the lower part of the piedmont zone. Very gentle sloping of 1 – 3% is in the pediplain area of North and SE of the watershed in addition the large area in the SW. <1% of nearly level area occupies about 40 % of the total area of the watershed and more pronounced in the central part (Figure IV.10).