CHAPTER 3

STUDY AREA, METHODOLOGY AND HYDROMETEOROLOGY

3.1 GENERAL

Erode town is the head quarters of Erode district, which was bifurcated from the composite Coimbatore district during the year 1979. This town was constituted as a municipality in the year 1871 and was elevated to special grade during the year 1980. Erode district is bounded by Namakkal district (the eastern side), Coimbatore district (the western side), Karnataka state (the northern side), Dindugal district (the southern side), Karur district (the southeastern side), Kerala state (the south western side), Nilagiri district (the north western side), Salem district (the north eastern side). The study area is located between $10^035'$ and $12^00'$ North latitudes and $76^050'$ and $77^050'$ East longitudes and 171.91 meters above mean sea level. It is positioned northwestern part of Tamilnadu and it is shown in Figure 3.1. The average rainfall in Erode region is 660.10 mm and total area is 8161.91 sq. kms. The population as per the 2001 census is 25,81,500. The area has a tropical climate with the highest and lowest temperature recorded in May and January respectively. The average maximum and minimum temperature is 96°F and 80°F. The northern part of Erode district is completely covered by hilly area with reserved forest (PWD 2002). The precipitation of this study area mainly depends upon Northeast monsoon. The major industries situated in Erode district are tanneries, paper, Co-operative processing mills, milk dairy project, sugar and chemical factories.
3.2 GEOLOGY

Erode district is a part of the uplands of the state. Physiographically the district can be divided into three areas. They are hilly areas, the uplands and the plains. The prominent geologic units identifiable in the district through interpretation of satellite imagery are 1) Basic rock, 2) Charnockite, 3) Rocks of complex gneiss and 4) Pink granite. These are presented in Table 3.1. Charnockite and complex gneiss are the major types in the study area (PWD 2002). Charnockite is mainly found in the hilly regions. Gneissic rocks occupy the centre portion of Erode district. Basic rocks are noticed at a few locations. Pink granite occurs as intrusive outcrops at a few places. These features are shown in Figure 3.2.
Table 3.1 Geology Area in Erode District

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Area in km²</th>
<th>Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Basic Rock</td>
<td>27.92</td>
<td>0.34</td>
</tr>
<tr>
<td>2</td>
<td>Charnockite</td>
<td>4548.81</td>
<td>55.73</td>
</tr>
<tr>
<td>3</td>
<td>Complex Gneiss</td>
<td>3543.63</td>
<td>43.42</td>
</tr>
<tr>
<td>4</td>
<td>Pink Granite</td>
<td>41.55</td>
<td>0.51</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>8161.91</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Figure 3.2 Geology in Parts of Erode District

3.3 SOIL

Soil is different from its parent rock sources as it is altered by multifarious interactions between the lithosphere, hydrosphere, atmosphere and the biosphere. The soils of the study area can be grouped under the following types: (1) Alluvial soil, (2) Brown soil, (3) Red calcareous, (4) Red non-calcereous, (5) Black soil and (6) Forest soil. These are presented in
Table 3.2. Red soil occupies the major part of Erode district. Two types of red soils namely red calcareous and red non-calcareous soils are found in the study area. (PWD 2002) The red calcareous soil occupies the centre portion and the red non-calcareous soil occupies the southern portion of the study area. Forest soil is found in the northern part. Alluvial soil is found all along the river courses. Black cotton soil exists here and there as patches. Brown soil is also found at a few locations. Various soil types are illustrated in Figure 3.3.

![Figure 3.3 Soil in Parts of Erode District](image)

**Table 3.2 Soil Area in Erode District**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Soil Classes</th>
<th>Area in km²</th>
<th>Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Alluvial Soil</td>
<td>100.83</td>
<td>1.24</td>
</tr>
<tr>
<td>2</td>
<td>Brown Soil</td>
<td>797.84</td>
<td>9.78</td>
</tr>
<tr>
<td>3</td>
<td>Red Calcareous Soil</td>
<td>4519.97</td>
<td>55.38</td>
</tr>
<tr>
<td>4</td>
<td>Red non-calcareous Soil</td>
<td>1499.74</td>
<td>18.37</td>
</tr>
<tr>
<td>5</td>
<td>Black Soil</td>
<td>163.97</td>
<td>2.01</td>
</tr>
<tr>
<td>6</td>
<td>Forest Soil</td>
<td>1079.56</td>
<td>13.22</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8161.91</strong></td>
<td><strong>100.00</strong></td>
<td></td>
</tr>
</tbody>
</table>
3.4 LINEAMENT

The Lineaments like joints, fractures etc., developing generally due to tectonic stress and strain, provide importance clue on surface features and are responsible for infiltration of surface run off into sub-surface and also for movement and storage of groundwater (Subba Rao et al 2001). Lineament patterns reflect orientations of joints and faults in a variety of geological settings. In general, areas with different lineament intensities have differences in probability of groundwater development potential, especially in the basement complex. Crystalline basement areas, high lineament-length density corresponds to areas of outcropping bedrock and thin regolith, where as low lineament-length density is indicative of buried bedrock and thick regolith. Areas underlain by a relatively thick regolith are significant from a hydrological point of view, because this deposit possesses a high degree of water storage capacity. Thus, lineaments represent the areas and permeability in hard rock areas. Such zones may have significance in the accumulation and movement of groundwater. Three sets of lineaments are noticed in the study area. Majority of the lineaments are trending NE-SW direction in the western part. Some of the lineaments are also trending NW-SE direction in the southern part and E-W trending lineaments are very few in number (PWD 2002).

For remote sensing of geological structures, lineaments are very critical. They are usually geomorphic linear features that denote breaks or fractures in geological structures. Lineaments are linear features that develop due to tectonic activities in a region. Lineament density can be used for a quantitative evaluation of relationships between lineaments and occurrence of groundwater. In the present study, lineaments were extracted from IRS-ID LISS-III images with 5.8 m spatial resolution using ERDAS Image 8.7. Lineaments are good rechargeable source and the studies have shown that
there are no significant intersections between the lineaments. The lineaments are found to be good for groundwater potential zones. This is because lineaments facilitate aquifer formation. Hence, in order to obtain lineament density zones in the study area, the lineament map as shown in Figure 3.4 is interpreted using satellite image IRS-ID LISS-III image.

![Figure 3.4 Lineament in Parts of Erode District](image)

3.5 LINEAMENT DENSITY

Based on the lineament density values, the study area was divided into five classes such as zones of very high, high, moderate, low, and very low prospect. Normally, larger the lineament density, greater is the permeability rate of groundwater.
3.6 GEOMORPHOLOGY

Groundwater recharge, transmission and discharge of the basin are controlled by the basin geomorphology, geology and structural patterns. It is possible to delineate various hydro geomorphic units for targeting groundwater from the satellite imageries through visual interpretation. Sreedevi et al (2001) has used the remote sensing and GIS techniques to study the occurrence of groundwater in Pageru River basin. Various geomorphology map of the study area was prepared from satellite imagery based on specific tone, texture, size, shape and association characteristics.

The northern part of Erode district is covered with reserve forest. Plateau is seen at a few locations in the reserve forest area. Pediment occupies the major portion of the study area. Shallow buried pediments, deep
pediments and buried pediments are noticed in some places. Erosional surface and depositional landforms are exposed in few areas.

Geomorphology is the predominantly influencing criterion for groundwater potential zoning. The landscape is built-up through tectonic uplift and volcanism. Denudation occurs by erosion and mass wasting, which produce sediments that are transported and deposited elsewhere within the landscape. Geomorphology of the study area was derived from a combination of information from Survey of India Toposheet (1:50,000) and the IRS-ID LISS-III resource image. Thirteen geomorphologic units were identified in the study area. Some of them are: reserved forest, escarpments, pediments, shallow buried pediments, deep buried pediments (PWD 2002). A geomorphology map showing all the 13 units is presented in Table 3.3 and Figure 3.6.

![Geomorphology in Parts of Erode District](image)

Figure 3.6 Geomorphology in Parts of Erode District
Table 3.3 Geomorphology Area in Erode District

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Area in km²</th>
<th>Area in (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Buried Pediments</td>
<td>221.98</td>
<td>2.7</td>
</tr>
<tr>
<td>2</td>
<td>Deep Pediments</td>
<td>594.92</td>
<td>7.3</td>
</tr>
<tr>
<td>3</td>
<td>Denudational Hills</td>
<td>15.73</td>
<td>0.2</td>
</tr>
<tr>
<td>4</td>
<td>Erosional Surface</td>
<td>15.86</td>
<td>0.2</td>
</tr>
<tr>
<td>5</td>
<td>Escarpments</td>
<td>13.72</td>
<td>0.2</td>
</tr>
<tr>
<td>6</td>
<td>Pediments</td>
<td>3325.66</td>
<td>40.7</td>
</tr>
<tr>
<td>7</td>
<td>Plateau</td>
<td>202.45</td>
<td>2.5</td>
</tr>
<tr>
<td>8</td>
<td>Reserved Forests</td>
<td>2328.49</td>
<td>28.5</td>
</tr>
<tr>
<td>9</td>
<td>Reservoirs</td>
<td>126.08</td>
<td>1.5</td>
</tr>
<tr>
<td>10</td>
<td>Residual Hills</td>
<td>46.3</td>
<td>0.6</td>
</tr>
<tr>
<td>11</td>
<td>Shallow Buried Pediments</td>
<td>1206.5</td>
<td>14.8</td>
</tr>
<tr>
<td>12</td>
<td>Structural Hills</td>
<td>33.38</td>
<td>0.4</td>
</tr>
<tr>
<td>13</td>
<td>Valley fills</td>
<td>30.84</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>8161.91</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

3.7 LAND USE - LAND COVER (LU/LC)

Land use describes how a piece of land is used for agriculture, settlements or industry whereas land cover refers to the material such as vegetation, rocks & water bodies that are present on the earth surface (Rokade et al 2004). Information on land uses and land cover are necessary for assessment of groundwater availability and its management. Land use is the expression of typical anthropogenic activities of the area. The Land use / Land cover map was derived from IRS-ID LISS-III standard FCC, which was geo-referenced with SOI Toposheets of 1:50,000 scale. The image was classified using ERDAS Image. The data used for developing the land use /
land cover map has been mentioned in the Table 3.4. The major LU/LC classes found are: built-up land, dense forest, water bodies, fallow land, land without scrub, open forest, single crop, shallow water, and stony waste. LU/LC in the study area is shown in Figure 3.7. This figure presents 13 different features of LU/LC and their corresponding areas appear in the Table 3.5.

Table 3.4 Details of Satellite Images

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Data type</th>
<th>Sensor</th>
<th>Scene</th>
<th>Path</th>
<th>Row</th>
<th>Date of acquisition</th>
<th>Resolution</th>
<th>Source of data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Digital data acquired by IRS-ID</td>
<td>LISS-III</td>
<td>1</td>
<td>100</td>
<td>65</td>
<td>13.02.05</td>
<td>23.5x23.5m</td>
<td>NRSA, Hyderabad</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>2</td>
<td>100</td>
<td>66</td>
<td>13.02.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>3</td>
<td>101</td>
<td>65</td>
<td>18.02.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>4</td>
<td>101</td>
<td>66</td>
<td>18.02.05</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3.7 Land Use / Land Cover in Parts of Erode District
The built-up lands are areas of human habitation developed for non-agricultural uses like building, transport, communication and utilities in association with water and vegetation lands. There are two settlements namely major and minor settlements distributed randomly in the study area. Erode is a major settlement located in the central part of the study area. The total area covered by the major and minor settlements constitutes 252.25 sq. km or 3.09 percent of the study area.

The dense forest is found on the northwestern part, northern part and northeastern part of the study area. The area under this category is about 119.74 sq. km or 1.47 percent of the study area.

Fallow lands are the lands which remain vacant without crop cultivation. These fallow lands are present in small patches spread over the study area and they are scattered. These occupy 730.05 sq. km or 8.94 percent of the study area.

The permanent fallow land features appear in yellow color. A large number of small permanent fallow lands exist in Erode district. The permanent fallow land area covers 1543.62 sq. km or 18.91 percent of the study area.

The land with scrub area is generally prone to ruin. The lands under this category are confined to the hills, upland/flat areas and also the forest boundary. These lands occur as patches stretching over the study area. The area under the category is about 1061.69 sq. km or 13.01 % of the study area.

The land without scrubs are found associated with higher topography and is formed due to degradation or erosion. It could be identified in the satellite data from its higher altitudes. The absence of vegetation distinguishes this category from the earlier mentioned one. The North,
Northwest and Northeastern parts of the area occur as stretching patches. They are under the category in about 355.79 sq. km or 4.36 percent of the study area.

Crop land is used for crops. It is also a good agriculture land. In the study area it occupies 451.74 sq. km or 5.53 percent.

Double crop include all agricultural area. The crops are found well distributed throughout the foothill zones and plain regions of the study area. These crops are totally distributed in the North, West, and East parts of the study area. The crops cultivated during these seasons are found distributed all over the study area and it occupies 346.92 sq. km or 4.25 percent of the study area.

Stony wastes are rocky exposures of varying lithological nature often stony and devoid of soil cover and vegetation. They occur among hill forests as openings or scattered as isolated exposure or loose fragments of boulders or as sheet rocks on uplands and plains. In the study area, these lands appear as brownish tone. These stony wastes are found in and around the hilly regions. The stony waste area covers 706.51 sq. km or 8.66 percent of the study area.

Both man-made and natural water features are included in the water body category. In this study area tanks are well distributed. The total area covers 12.02 sq. km or 0.15 percent of the study area.

Barren rocky area contains forest, glades and old field. It provides no shelter or sustenance. A wild and uninhabited area left in its natural condition is called barren rocky area. It covers 102.19 sq. km or 1.25 percent of the study area.
Forest plantation is indicated in green colour in land use / land cover map. The total area covered by forest plantations are 2375.77 sq. km or 29.11 percent of the study area.

Sandy area appears in light color in land use / land cover map. Total sandy area corresponds to 103.62 sq. km or 1.27 percentage of the study area.

**Table 3.5 Land Use / Land Cover Area in Erode District**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Area in km²</th>
<th>Area in (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Built-up land</td>
<td>252.25</td>
<td>3.09</td>
</tr>
<tr>
<td>2</td>
<td>Water bodies</td>
<td>12.02</td>
<td>0.15</td>
</tr>
<tr>
<td>3</td>
<td>Dense forest</td>
<td>119.74</td>
<td>1.47</td>
</tr>
<tr>
<td>4</td>
<td>Fallow land</td>
<td>730.05</td>
<td>8.94</td>
</tr>
<tr>
<td>5</td>
<td>Barren rocky</td>
<td>102.19</td>
<td>1.25</td>
</tr>
<tr>
<td>6</td>
<td>Forest plantation</td>
<td>2375.77</td>
<td>29.11</td>
</tr>
<tr>
<td>7</td>
<td>Permanent fallow land</td>
<td>1543.62</td>
<td>18.91</td>
</tr>
<tr>
<td>8</td>
<td>Crop land</td>
<td>451.74</td>
<td>5.53</td>
</tr>
<tr>
<td>9</td>
<td>Stony waste</td>
<td>706.51</td>
<td>8.66</td>
</tr>
<tr>
<td>10</td>
<td>Double crop</td>
<td>346.92</td>
<td>4.25</td>
</tr>
<tr>
<td>11</td>
<td>Sandy area</td>
<td>103.62</td>
<td>1.27</td>
</tr>
<tr>
<td>12</td>
<td>Land without scrub</td>
<td>355.79</td>
<td>4.36</td>
</tr>
<tr>
<td>13</td>
<td>Land with scrub</td>
<td>1061.69</td>
<td>13.01</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>8161.91</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

**3.8 SLOPE**

The entire area is a vast stretch of rolling plain. The average elevation is 900 m above MSL. Over 80% of the study area has a slope ranging from 0 - 2°. Steep slope occurs towards Northeast and North directions where a few hillocks were located. Slope plays a key role in groundwater infiltration. They are inversely related. Steeper the slope, greater
will be the runoff and hence lesser will be the groundwater recharge. The identified slope categories ranged from 1 to > 24 degrees. The slope in the study area was classified into five categories for the present study viz., <2°, 2-5°, 5-12°, 12-24° and > 24°. The Northeastern and Northern part of the study area was found to have poor groundwater prospects owing to high slope gradient. All other parts of the study area, except few locations, has good groundwater prospect owing to gentle slope, i.e., <2°. The slope structure of the study area is indicated in Figure 3.8.

![Figure 3.8 Slope in Parts of Erode District](image)

### 3.9 DRAINAGE

Drainage was digitized from SOI Toposheets of 1:50,000 scale for the present study. Groundwater prospects were found to be good in very high drainage density zones where lineaments are located parallel to the drainage channel. Areas with low slopes viz. gradients with lower drainage density
permuted more infiltration and recharge of groundwater. Hence, they had higher groundwater potential. The drainage map is shown in Figure 3.9.

Figure 3.9 Drainage in Parts of Erode District

3.10 DRAINAGE DENSITY

Drainage density is a measure of how well or how poorly the stream channels drain a watershed. Drainage density depends upon both climate and physical characteristics of the drainage basin. Soil permeability and underlying rock type affect the runoff in a watershed; impermeable ground or exposed bedrock would lead to an increase in surface water runoff and therefore, will lead to more frequent streams. Drainage density is calculated from two parameters 1) the total area of the respective basin and 2) total length of all the streams and rivers in a drainage basin. Drainage density can also be defined as a measure of length of stream (channel) per unit area of
the drainage basin. The distribution of the various density classes are shown in Figure 3.10.

![Drainage Density in Parts of Erode District](image)

**Figure 3.10 Drainage Density in Parts of Erode District**

### 3.11 METHODOLOGY

The base map of the study areas was generated using the Survey of India (SOI) topographical maps bearing No’s 16A/13, 16A/14, 16A/15, 16E/1, 16E/2, 16E/3, 16E/5, 16E/6, 16E/7, 16E/8, 16E/9, 16E/10, 16E/12, 16E/14, 16E/15, 16E/16, 16F/5, 16F/6, 16F/9, 16F/10, 16F/13 and 16F/14 in 1: 50000 scale. Figure 3.11 shows the methodology followed in this study.

The rainfall, groundwater level data and pumping test data were collected from State Ground and Surface Water Resource Data Centre, Tamil Nadu, for the period from 1997 to 2010 (14 years) and were used to find the relationship between rainfall and groundwater level. The groundwater quality was assessed by collecting and testing groundwater samples, by the
procedures prescribed in IS: 3025 – 1983, from one-forty-four (144) sampling station during the month of February 2007 (Postmonsoon) and May 2007 (Premonsoon).

Suitability of the groundwater samples for drinking purpose was interpreted by the limitations prescribed by IS: 10500 – 1991 (Drinking water standard) and WQI. Irrigation water quality interpretation was based on Sodium Adsorption Ratio (SAR), USSL classification, Donnen’s classification and Wilcox’s classification. The influence of anions and cations were analyzed using Piper diagram and by statistical analysis.

Drainage map and contour map of the study area was prepared from survey of India topographic maps in 1: 50000 scale. The geomorphology, geology, soil and lineament maps were prepared on 1: 50000 scales based on the maps published by State ground and surface water resources data centre, Chennai. Land use and land cover map was prepared using geocoded IRS-1D LISS-III FCC imagery on 1: 50000 scale. The thematic maps geomorphology, geology, soil, land use and land cover, drainage density, lineament density and slope of the study area was overlaid using weighted overlay analysis and a groundwater potential map was prepared.

Electrical resistivity survey was carried out by taking Vertical Electrical Soundings (VES) at seventy-five various locations in the study area. Based on the apparent resistivity and processed VES results, groundwater was explored by four methods. In the first method weathered layer map was overlaid on depth to basement map, in the second method lineament density map was overlaid on depth to basement map , in the third method weathered layer, depth to basement and lineament density maps were overlaid and the fourth method is by the isoresistivity contours.
**Figure 3.11 Flow chart for the Methodology**
Groundwater model has been developed for the study area using MODFLOW for the effective management of groundwater and optimum location for recharging wells in order bring up the quality level of groundwater.

3.12 HYDROMETEOROLOGY

Monitoring of groundwater levels forms an important component of groundwater survey. The water level fluctuation reflects the change in groundwater storage. The rise and fall in water levels depend upon the amount, duration and intensity of rainfall, depth of weathering, specific yield of the formation and the general slope of the fresh rock formations towards drainage channel. The water level fluctuation can be studied from the hydrograph drawn from the water levels taken from the borewells. The graphical representation (Sinha et al 2006) of the water table dynamics is called hydrograph of the well. The groundwater level mainly depends upon the rainfall. So this chapter describes the comparison between groundwater level and rainfall.

3.13 HYDROSTRATIGRAPHY

Erode district is underlain entirely by Archaean crystalline formations with recent alluvial deposits occurring along the river and stream courses and colluvium of valley fills. The important aquifer systems in the district are constituted by weathered, fissured and fractured crystalline rocks and the recent alluvial deposits. The porous formations in the district are represented by alluvium and colluvium. The maximum saturated thickness of alluvial aquifer is up to 5 m. The area lying at the foot hill zones which are seen in the northern parts of the study area is underlain by the colluvial material derived from the nearby hill ranges comprising sands and gravels. The maximum saturated thickness of the colluvial aquifer is up to 20 m. The
hard consolidated crystalline rocks of Archaen age represent weathered, fissured and fractured formations of gneisses, granites, charnockites and other associated rocks. Groundwater occurs under phreatic conditions in the weathered mantle and under semi confined conditions in the fractured zones. The thickness of the weathered mantle of the rock is varying from less than a meter to as much as 30 m. It is within the depth of 20 m in major part of the district while in the western and extreme north, northeastern parts of the district, they are more than 20 m (CGWB 2008).

3.14 RAINFALL CHANGES

The average annual rainfall of this district is 660.10 mm from four distinct seasons viz., winter, hot weather period, southwest monsoon and northeast monsoon. The district receives the rain under the influence of both southwest and northeast monsoons. The northeast monsoon chiefly contributes to the rainfall in the district. The southwest monsoon is also reasonable. During the winter and hot seasons, the rainfall is scanty. The normal annual rainfall over the district varies from about 575 mm to about 833 mm (CGWB). It is the minimum in the southern and southeastern parts of the district around Kodumudi (575.3 mm), Mulanur (581.0 mm) and Dharapuram (593.0 mm).

3.15 GROUNDWATER LEVEL FLUCTUATION

The water level fluctuation is also controlled by the intensity of the rainfall and as well as by pumping. The study of water level fluctuation helps to assess the gravity of the situation in times of drought and also to take appropriate remedial measures. Water level increases during monsoon period and decreases during hot weather period. In recent years, the declining water levels and reduction in yields of wells are being observed due to increased
extraction of ground water through large number of wells for irrigation purposes.

3.16 COMPARISON BETWEEN RAINFALL AND GROUNDWATER LEVEL

A water level undulation in a well depends upon the rate of recharge and discharge in the aquifer. For this purpose, 23 observation bore wells maintained by Public Works Department, Tamilnadu as shown in Figure 3.12 are selected to evaluate the groundwater level fluctuations from 1997 to 2010. Similarly 13 raingauge stations namely Ammapet, Bhavani, Bhavanisagar, Chennimalai, Dharapuram, Erode, Gobichetipalayam, Kangayam, Kavundapadi, Periyakodiveri, Mulanur, Perundurai and Sathiyamangalam were selected for the measurements of rainfall in the study area which is shown in Figure 3.13.

Figure 3.12 Observation Borewell Locations of the Study Area
3.17 RESULTS AND DISCUSSION

3.17.1 Rainfall

The rainfall pattern, as recorded in the rainfall stations, indicates that the precipitation is mostly uncertain, uneven or unequally distributed. The rainfall distribution of 13 raingauge stations is shown in Figures 3.14 to 3.26. From the figures the stations Ammapet, Bhavani, Erode, Gobichetipalayam, Kangayam, Mulanur, Chennimalai, Perundurai and Sathiyamangalam have recorded high rainfall in the year 2005. The stations Ammapet, Dharapuram, Erode, Perundurai and Sathiyamangalam have recorded low rainfall during the year 2002. In Bhavanisagar station the rainfall was high in the year 2000 and low in the year 2010. Kavundapadi has maximum and minimum rainfall in the year 2004 and 2010 respectively and also rainfall observed in Periyakodiveri was maximum in the year 2000 and minimum in the year 2004. In general, the rainfall pattern indicates that the district had received
maximum rainfall during the year 2005 and minimum rainfall during the year 2002.

Figure 3.14 Annual Rainfall for Ammapet Station

Figure 3.15 Annual Rainfall for Bhavani Station
Figure 3.16 Annual Rainfall for Bhavanisagar Station

Figure 3.17 Annual Rainfall for Chennimalai Station
Figure 3.18 Annual Rainfall for Dharapuram Station

Figure 3.19 Annual Rainfall for Erode Station
Figure 3.20 Annual Rainfall for Gobichetipalayam Station

Figure 3.21 Annual Rainfall for Kangayam Station
Figure 3.22 Annual Rainfall for Kavundapadi Station

Figure 3.23 Annual Rainfall for Periyakodiveri Station
Figure 3.24 Annual Rainfall for Mulanur Station

Figure 3.25 Annual Rainfall for Perundurai Station
3.17.2 Water Level

The wells HP1E01, HP1E02 and HP2E23 had recorded maximum water level in the year 2000 (3.3 m bgl, 3.2 m bgl and 3.7 m bgl respectively). Similarly the wells HP1E07, HP1E09, HP2E17 and HP2E22 had recorded higher water level in the year 2007 (5.7 m bgl, 1.5 m bgl, 5.1 m bgl and 4.2 m bgl respectively). In the year 2006, the wells HP1E11, HP2E09, HP2E20 and HP2E21 (4.5 m bgl, 4.8 m bgl, 7.7 m bgl and 5.9 m bgl respectively) reached increased water level. The wells HP2E05, HP2E11, HP2E26 and HP2E28 (1.9 m bgl, 5.3 m bgl, 5.0 m bgl and 3.4 m bgl respectively) attained more water level in the year 1997. In the year 2010, the water level in HP2E12, HP2E18 and HP2E27 (2.4 m bgl, 3.5 m bgl and 1.6 m bgl respectively) was high.

The minimum water level was observed in HP1E01, HP1E08, HP1E11, HP2E04, HP2E12, HP2E18, HP2E19, HP2E21, HP2E22, HP2E23, HP2E27 and HP2E29 during the year 2004 (20.0 m bgl, 7.7 m bgl, 16.5 m bgl, 9.4 m bgl, 11.0 m bgl, 9.5 m bgl, 19.9 m bgl, 12.2 m bgl, 28.5 m bgl, 37.7 m bgl, 6.5 m bgl and 5.5 m bgl respectively). Similarly the wells HP1E02,
HP1E09, HP2E09, HP2E11, HP2E28 (23.2 m bgl, 8.0 m bgl, 9.3 m bgl, 12.8 m bgl and 8.7 m bgl respectively) had recorded minimum water level during the year 2003. Figures 3.27 to 3.49 show the water level fluctuations in bore wells at various locations. The water level data shows that the level in the study area is not uniform and is fluctuating. The bore wells recorded maximum level at different years whereas the minimum levels in most of the bore wells were either during 2004 or 2003.

**Figure 3.27 Groundwater Level for the Well HP1E01**

**Figure 3.28 Groundwater Level for the Well HP1E02**
Figure 3.29 Groundwater Level for the Well HP1E07

Figure 3.30 Groundwater Level for the Well HP1E08
Figure 3.31 Groundwater Level for the Well HP1E09

Figure 3.32 Groundwater Level for the Well HP1E11
Figure 3.33 Groundwater Level for the Well HP2E04

Figure 3.34 Groundwater Level for the Well HP2E05
Figure 3.35 Groundwater Level for the Well HP2E09

Figure 3.36 Groundwater Level for the Well HP2E11
Figure 3.37 Groundwater Level for the Well HP2E12

Figure 3.38 Groundwater Level for the Well HP2E16
Figure 3.39 Groundwater Level for the Well HP2E17

Figure 3.40 Groundwater Level for the Well HP2E18
Figure 3.41 Groundwater Level for the Well HP2E19

Figure 3.42 Groundwater Level for the Well HP2E20
Figure 3.43 Groundwater Level for the Well HP2E21

Figure 3.44 Groundwater Level for the Well HP2E22
Figure 3.45 Groundwater Level for the Well HP2E23

Figure 3.46 Groundwater Level for the Well HP2E26
Figure 3.47 Groundwater Level for the Well HP2E27

Figure 3.48 Groundwater Level for the Well HP2E28
3.17.3 Comparison between Rainfall and Groundwater Level

To study the relationship between groundwater level and rainfall, seven raingauge stations which are in close proximity to seven observation wells were compared and are shown in Figures 3.50 to 3.56.

Rainfall from Ammapet station was compared with groundwater level of well HP1E01 which is shown in Figure 3.50. From the year 1997 to 2000 rainfall decreased (1048.8 mm to 769 mm) but the corresponding water level in that years increased (9.3 m bgl to 3.3 m bgl). In the year 2006 to 2010 rainfall increased and decreased alternatively (821.4 mm, 766 mm, 1076.8 mm, 701.4 mm and 888 mm respectively), correspondingly the water level also increased and decreased alternatively (9.9 m bgl, 11 m bgl, 8.8 m bgl, 9.8 m bgl and 9.6 m bgl respectively).
Figure 3.50 Comparison between Station Ammapet and HP1E01 Well

Rainfall from Bhavani station was compared with groundwater level of well HP2E05 which is shown in Figure 3.51. The water level in this location varied from 1.9 m bgl to 8.2 m bgl. The rainfall was maximum in the year 2005 (1418.6 mm). The water level was 8.2 m bgl. The rainfall was minimum in the year 2003 (501.2 mm) and the water level was 6.0 m bgl. From the year 2001 to 2003 rainfall decreased (721 mm, 589.3 mm and 501.2 mm) and the water level also decreased (3 m bgl, 4.7 m bgl and 6 m bgl).

Figure 3.51 Comparison between Station Bhavani and HP2E05 Well
Rainfall from Dharapuram station was compared with groundwater level of well HP2E26 which is shown in Figure 3.52. The water level in this location varied between 5 m bgl and 29 m bgl. Peak rainfall was observed during the year 2005 (1047.7 mm). At that period the water level was 15 m bgl. The minimum rainfall was noted during the year 2002 (342.5 mm) with corresponding water level of 24.8 m bgl. From 2007 to 2010, rainfall fluctuated alternatively (849 mm, 1155.8 mm, 831 mm and 882 mm respectively), corresponding water level also fluctuated alternatively (13.6 m bgl, 5.9 m bgl, 29 m bgl and 13.2 m bgl respectively).

![Figure 3.52 Comparison between Station Dharapuram and HP2E26 Well](image)

Rainfall from Kangayam station was compared with groundwater level of well HP2E11 which is shown in Figure 3.53. The water level fluctuated from 5.3 m bgl to 12.7 m bgl. The rainfall was high and low during 2005 (1026.7 mm) and 2010 (299 mm) with the corresponding water level of 10.4 m bgl and 7.5 m bgl respectively. The rainfall decreased from 2000 to 2002 (607.6 mm, 500.6 mm and 326.4 mm) and the water level also decreased (8.5 m bgl, 10.1 m bgl and 10.9 m bgl).
Rainfall from Mulanur station was compared with groundwater level of well HP2E27 which is shown in Figure 3.54. The groundwater level in this location varied from 1.6 m bgl to 6.5 m bgl. The rainfall during 2005 (946.2 mm) and 2003 (349.5 mm) was maximum and minimum with the water level of 4 m bgl and 6.4 m bgl respectively. The rainfall in 2004, 2005 2006 and 2007 are 412.6 mm, 946.2 mm, 468.2 mm and 611.4 mm respectively with the corresponding groundwater level of 6.5 m bgl, 4 m bgl, 4.2 m bgl and 2.4 m bgl.
Rainfall from Perundurai station was compared with groundwater level of well HP1E07 which is shown in Figure 3.55. The groundwater level in this location varied from 5.7 to 28.3 m bgl. The rainfall was maximum during 2005 (1086.5 mm). A water level of 14 m bgl was recorded during that period. During 2002, minimum rainfall was recorded (505 mm) and the water level reduced to 20.3 m bgl. The rainfall decreased (1062 mm, 734 and 505 mm) with corresponding decrease in water level (15.5 m bgl, 17.8 and 505 m bgl) during the years 2000, 2001 and 2002.

![Figure 3.55 Comparison between Station Perundurai and HP1E07 Well](image)

Rainfall from Periyakodiveri station was compared with groundwater level of well HP2E17 which is shown in Figure 3.56. The water level in this place fluctuated from 5 m bgl to 16.3 m bgl. The rainfall was at its maximum during 2000 (936 mm) and minimum during 2004 (328 mm). The water level during those periods was 15.9 m bgl and 10.6 m bgl respectively. The rainfall increased and decreased (374 mm, 641 mm, 494 mm and 611 mm) alternatively from the year 2006 to 2009 with corresponding increase and decrease in water levels (7.5 m bgl, 5.1 m bgl, 6.7 m bgl and 5.6 m bgl).
All the above comparison mostly establishes positive relation between rainfall and water level in the study area.

Figure 3.56 Comparison between Station Periyakodiveri and HP2E17 Well