CHAPTER 2

HYDROGEOOMORPHOLOGY

2.1 PHYSIOGRAPHY

Evaluation of physiographical factors such as topography, soils, bedrock structure, hydrology, including surface and ground water drainage and climatic conditions are of great importance in the study of urban water.

Madras districts forms a part of Tamil Nadu coastal plains. Major part of the land has a flat topography with very gentle slope towards East. The altitudes of land surface varies from 10 m above m.s.l. in the west to sea level in the east. Fluvial marine and erosional land forms are noticed in the district. Marine transgressions and regressions and non-tectonic activity during the recent past have influenced the morphology and resulted in present landform. Meandering streams with small sand bars are present along the course of Adayar river. The river shows some sharp angular trends which may indicate some hidden structural features. The man made bunds and shutters in the mouth of the river control flood water and landward movement of sea water has changed the natural erosional processes. The pediment and buried pediment in Guindy area, in and around the reserved forest is the only undisturbed area because of the less disturbance to the ecology whereas in other areas the ecology is totally disturbed by built-up area with large scale human interference and pollution. A number of surface water bodies which existed in the district in the early period of this century have been filled up.
(eg. Valluvar Kottam, Kotturpuram, etc.) The sand dunes and ridges have also been converted into residential areas. Marina Beach is the most natural beach in the world with a width varying from 150 to 600 m and a length of about 5.6 Kms. has also been encroached by human activity. The marshy land and lagoon north of Adayar river has also been transformed into built-up area. Theosophical society in Adayar has preserved natural geomorphology, sand dunes, beach ridges, flora etc. within their premises.

Madras Port with jetty has reportedly influenced the wave action pattern in recent times. The wave cut cliffs are seen near North Madras coast where the beach landform have completely been eroded. The sea erosion is maximum during the cyclone period.

2.2 DRAINAGE

2.2.1 Surface drainage

The Cooum and the Adayar are the two principal non-perennial rivers flowing across the city. Adayar river originates at the confluence of two streams in Thiruneermalai that drain at the upstream area of Chembarambakkam reservoir (Tank). It is a small river of 422 Kilometres length. The Cooum runs through the middle of the city from east to west and almost bisects the city into two halves while the Adayar river is in the South. Though the two rivers are non-perennial, they have a substantial flow during the monsoon and play a major role during floods. Due to the action of self driven sand, which is the characteristic feature of the Corommandel coast both the rivers have developed sand bars across their mouths. There are two other notable water bodies traversing the city, the Buckingham Canal and the Otteri
Nullah. The Buckingham canal built in the latter part of the 19th century was meant to serve as a navigational canal. It runs close to the coast, nearly parallel to it and is connected to the Cooum and Adayar rivers near their mouths. The Otteri Nullah starts from a tank in Villivakkam 20 Kms. west of the city, and joins the Buckingham canal at Basin Bridge. Much of the city's sewage flow into these stagnant water courses and large quantities of solid filth has consequently accumulated on the beds of the rivers, raising them much above their natural level. These have become cess pools breeding unwanted bacteria. Likewise the banks of the water courses have been occupied by slums and almost all the domestic wastes are dumped into these channels. Many tanks in the peripheral parts of the city are partially or fully silted. Madras had hundreds of small tanks which had been acting as breeding place for Malarial mosquitoes. Some of these tanks like Velachery Tank, Saidapet Tank, Kodambakkam Tank, Mandaveli Tank, Veyasarpadi Tank, Otteri Tank, etc. are now used as dumping sites for solid wastes. The flow volume of effluent contaminated water in Cooum and Adayar River has not been measured by any agency.

2.2.2 Subsurface

The alluvial deposits are highly permeable, and are underlain by stiff clay conducive for artesian water as revealed in several bore well lithologs in and around Madras city. Water is found in all parts at a few places above or below MSL. These alluvial deposits of varying thickness make it difficult to predict with any certain properties such as water bearing capability, percolation rates, shrinkage etc. Water bearing aquifers have been located in Minjur, Panjetty, Tamaрапakkam, in north and west of the city and at Thiruvanmiyur in the South. These aquifers are estimated to have dependable potential yield
Fig. 2.1
of 155 million lpd. It has also been observed that the interface between salt and freshwater has moved inland (MMWSSB, 1983).

2.3 LAND USE

The land use pattern of the city plays an important role in this study. The available records have given the distribution of landuse pattern of the city in 1964 and 1974 and are shown in the following tables (Table 2.1 & 2.2).

Table 2.1 Net inward migration in the city of Madras 1921 - 1978

<table>
<thead>
<tr>
<th>CENSUS YEAR</th>
<th>MALE</th>
<th>FEMALE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1921 - 31</td>
<td>70,000</td>
<td>54,000</td>
<td>1,24,000</td>
</tr>
<tr>
<td>1931 - 41</td>
<td>41,000</td>
<td>37,000</td>
<td>78,000</td>
</tr>
<tr>
<td>1941 - 51</td>
<td>2,80,000</td>
<td>2,60,000</td>
<td>5,40,000</td>
</tr>
<tr>
<td>1951 - 61</td>
<td>58,000</td>
<td>42,000</td>
<td>1,00,000</td>
</tr>
<tr>
<td>1961 - 71</td>
<td>2,84,000</td>
<td>2,66,000</td>
<td>5,50,000*</td>
</tr>
<tr>
<td>1971 - 78</td>
<td>1,82,000</td>
<td>1,80,000</td>
<td>3,62,000*</td>
</tr>
</tbody>
</table>

Source : Census of India 1961

* Estimated Figure MMDA.

Table 2.2 Changes in major landuse pattern - Madras city 1964-74

<table>
<thead>
<tr>
<th>LAND USE</th>
<th>1964 Area(Ha)</th>
<th>%age</th>
<th>1974 Area(Ha)</th>
<th>%age</th>
<th>Increase/Decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>4303</td>
<td>33.3</td>
<td>6837</td>
<td>53.3</td>
<td>58.9</td>
</tr>
<tr>
<td>Commercial</td>
<td>412</td>
<td>3.2</td>
<td>548</td>
<td>4.2</td>
<td>33.1</td>
</tr>
<tr>
<td>Industrial</td>
<td>490</td>
<td>3.8</td>
<td>743</td>
<td>5.7</td>
<td>51.6</td>
</tr>
<tr>
<td>Institutional*</td>
<td>3700</td>
<td>28.8</td>
<td>2160</td>
<td>16.7</td>
<td>-41.6</td>
</tr>
<tr>
<td>Open Space**</td>
<td>3970</td>
<td>30.9</td>
<td>2594</td>
<td>20.1</td>
<td>-34.7</td>
</tr>
</tbody>
</table>

Total : 12883 100.0 12883 100.0

Source : MMDA, 1980*
This category includes public and semi public use, utility service and transport and communication.

** This category includes vacant land and non-urban uses.

** TABLE 2.3 Madras city houses and household 1961-81

<table>
<thead>
<tr>
<th>Census Year</th>
<th>Population</th>
<th>Residential Units (in lakhs)</th>
<th>Households (in lakhs)</th>
<th>Persons per household</th>
<th>Persons per household</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>17,29,141</td>
<td>1.41</td>
<td>3.50</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>1971</td>
<td>24,69,449</td>
<td>3.38</td>
<td>4.45</td>
<td>5.5</td>
<td>7</td>
</tr>
<tr>
<td>1981</td>
<td>32,66,034</td>
<td>4.76</td>
<td>5.68</td>
<td>5.7</td>
<td>7</td>
</tr>
</tbody>
</table>

Source: MMDA, 1980

The table in the middle shows the major changes in the landuse that were recorded during that decade.

2.3.1 Commercial land use

Commercial land uses occupied 3.2% area of the total area of the city in 1964 and increased to 4.28% by 1974. In the main commercial core of the city, the central business district (CBD), are concentrated the major commercial activities, next in importance Mount Road, the fashionable Shopping Centre in Madras city, Triplicane, Mylapore, Mambalam, Veppery, Purasawalkam, Egmore and Chindadripet. With the spread of residential areas outside the city limits, new commercial areas mostly retail have come up, mostly as linear developments along the transportation arteries. These commercial areas serve the nearby newly developed residential areas and hamlets.
2.3.2 Industrial land use

Industrial land use occupied only 3.8% of the total area in 1964 and increased to 5.7% in 1974. There are about 6,300 (Directorate of Industries, 1980) small and medium scale industries in the city of which 92% are small scale. Small and medium industrial establishments are concentrated mainly in the northern, North-western and southern parts of the city. These industries in Madras city are diversified in nature and are mostly service and light industries.

2.3.3 Institutional land use

Institutional land use accounted for about 28.8% of the total area in 1964 and this declined to 16.7% in 1974, when the number of persons engaged by them increased by 40%. The apparent decline is most likely due to changes in definition and it is also possible that some publicly owned land (formerly classified as institutional) was released for other uses during the period. In Madras, institutional land use mainly includes institutions related to education, health, social organisations, etc. Health institutions such as hospitals, nursing homes and clinics consume about 1000 lpcd of water per day. In Madras there are about 15 major government hospitals, two Employees State Insurance hospitals and 31 dispensaries. There are also 265 registered private nursing homes of varying bed strength, functioning on a commercial basis and 4 aided private hospitals (Statistical hand book of Madras, 1980 p.36).

The corporation of Madras has a separate health department. It is operating one hospital and 147 dispensaries.
2.3.4 Recreational use and open spaces

According to the Corporation of Madras, there are 73 parks and 78 play-grounds, or one park and one play-ground for every 40,000 people. Many of these are in bad shape. There are 79 cinema theatres and 42 auditoriums of all types. There are about 450 places of entertainment and 1,060 places of worship. Apart from this Madras has its sprawling beaches.

Open spaces occupies 30.9% of the total extent area in 1964 and 20.1% in 1974. This decline of 10% in the land remaining as open spaces may be most probably due to the conversion of vacant and non-urban land, rather than a decline in the amount of land allocated for formal recreational open space purposes.

2.3.5 Metro structures : settlements (residential landuse)

Land put to residential uses accounted for 33.3 percent in 1964 and 53.3% in 1947. The increase in land put to residential use clearly indicates the vertical and horizontal growth of the city. Rapid growth of population and development in the transportation facilities influenced the growth of new residential colonies which have actually sprawled beyond the corporation limits of the city.

According to 1971 census, Madras city had 3,38,000 houses of which 25.7% were kutch houses or huts. Of the pucca houses about 22% were over 50 years old, which can be considered as the normal life span of a house. So in 1971, Madras city had 1,90,000 pucca houses in good condition as against 4,45,000 households. According to the Corporation of Madras the city had
4,46,000 residential units in 1981, against 5,68,000 households, with an average of 7 persons per house.

The city's population has been growing at an average annual rate of 3.5% and this had added 1,09,000 new houses with 1,23,000 new households assuming that about 10,900 dwelling units have been added annually.

The varying densities of population show the intensity of residential development in different parts of the city. George town, being the main nerve Centre of the city is the most thickly populated area of the city.

2.3.6 Transportation

Transportation is an important service essential for any urban developmental activity. Intensification of urbanisation followed by the highly commercial and industrial activities advantageously placed in city because of its good transportation network covering 2,344.975 kilometres of roads and streets accounting for 18.5% of the land.

The national highways (No.4, 5 and 45) converge into the city from the north-west and south. A number of other roads which link them cover the city like a spider's web.

The Madras Central and Madras Egmore stations are the principle passenger terminals of the broad gauge and meter gauge railway line respectively. The railways also operate city suburban electric train services in all the three directions.
The only available waterway is the Madras harbour. It handles more than 80% of the States import and export cargo. Though Madras city has a good transportation network, the traffic and transportation problem is getting acute day by day. The rapid growth of secondary and tertiary urban activities along the transport corridors has resulted in continuous ribbon development and the narrowing of carriage way has considerably limited to service utility. In the city's transportation network nearly 40% are narrow streets. (886.315 Kms.).

This part of the study has given the significance of landuse discouraging recharging of groundwater. It has been found that the city has only 20 percentage of open space for proper recharge. Even due to the dumping of wastes by the public the effective component of recharge would have been further reduced.

2.4 Remote sensing studies in ground-water resources and integrated approach

The mobility and stability of ground water is governed by different factors like lithology, texture, structure, geomorphology and surface water resources and hence for the groundwater surveys an in depth understanding of all these parameters are essential in which application of remote sensing techniques plays an important role. Groundwater exploration can be carried out successfully as detailed below, theme after theme sequentially and integrating them finally. The following tasks can be accomplished using this technique.

1. Lithological Making.
2. Structural trend line mapping and identification of exposed and concealed geological structures.

3. Lineament mapping and classification of these lineaments as extensions, shear and release fractures by integrating the structural trends.

4. Analytical rigor of such lineament by preparing various lineament density contours.

5. Correlation of ground measured water table with above data and identification of areas, zones and directions of ground-water movement.

6. Mapping of various denudational structures and fluvial landform including buried channels loosing and gaining streams recharge area etc.

7. Preparation of land use map and integration of all the above information to identify target areas for ground water exploration.

2.5 Factors encouraging recharge

The following are the favourably conditions for natural recharge.

1. A formation of sand, gravel or highly fractured rocks either underground or exposed over a large area or in stream channel helps in the recharge of ground water.
2. The presence of caverns, fractured or faulted zones or numerous small cavities in rock formations (limestone areas) either underground or exposed on the land surface or stream channels.

3. Karst or sinkhole topography.

4. The absence of barriers for horizontal or vertical movement of ground water.

5. Feasible locations for installation of recharge wells, dams, diversion or other recharge structures.

6. Wide braided streaming, broad alluvial fans and glaciofluvial deposits may provide excellent opportunities for water spreading.