# CHAPTER 1

# INTRODUCTION

## 1.1 GENERAL

Water is essential to people, and the largest available source of fresh water is groundwater. Increasing demand for water has stimulated development of groundwater resources and improvement of techniques for investigating the occurrence and movement of groundwater. For such investigations, geological and geomorphological studies of a terrain are important, since they play a major role in controlling its groundwater condition. Further, many research studies have contributed to the better understanding of the groundwater characteristics of a terrain. Adyalkar (1976) stated that three principal factors, namely geologic setting, physiographic features and climate, control the groundwater condition of a terrain. During the $20^{th}$ century, the advent of satellite remote sensing technology augmented the pace of groundwater research. The synoptic view and repetitive coverage provided by remotely sensed image data help to understand the geological and geomorphological setting of a terrain and their significance in the study of groundwater condition (Rao, 1978). In a similar study using Landsat TM data, Ravi Prakash and Mishra (1993) delineated geomorphological units for groundwater exploration. Lafleur (1999) has emphasized the role of geomorphic units in controlling groundwater flow in a given region. The importance of streams, lakes, and wetlands on groundwater flow has been explained by Winter (1999). Integrated study of remote sensing derived spatial information and collateral data like water level, water quality, bore hole log, soil *etc.*, could be made more sensible using Geographic Information System (GIS), while also acting as a valuable tool in natural resources assessment and environmental monitoring (Burrough, 1986).

## 1.2 NEED FOR THE STUDY

Previous research on the utility of GIS explains the importance of these recent techniques in groundwater studies. A few such studies include satellite data and GIS for land use classification (Shih, 1988), integration of remote sensing, Global Positioning System (GPS) and GIS techniques to understand the coastal environment (Welch, 1992), spatial analysis of geochemical, bore hole and remote sensing information for groundwater development (Gustafsson, 1993), watershed management strategies (Rondal *et al.*, 1994), and remote sensing and GIS for groundwater exploration in developing countries (Timothy *et al.*, 1994). Most of these studies have laid emphasis on the occurrence of groundwater, its recharge and discharge mechanism and watershed management, and not on seasonal variations in groundwater head and quality - an essential factor - since groundwater condition varies seasonally. Such a study of seasonal behavior of groundwater environment will help to understand the short-term and long-term changes in groundwater quality and quantity. This is applicable to countries like India where the monsoon is erratic and seasonal variations in groundwater abstraction and recharge are large. Hence, the present study attempts to understand the applicability of integrated remote sensing and GIS techniques for studying seasonal changes in groundwater condition (groundwater level and groundwater quality) and to understand the relationship between groundwater condition and land use practice of a terrain.

## 1.3 SCOPE OF PRESENT STUDY

The present study has been conducted to delineate potential groundwater zones and study the short-term and long-term variations in groundwater level and groundwater quality using remote sensing and GIS techniques. Further, the groundwater potential zones and groundwater quality therein are compared with the land use practice of the terrain to understand their interrelationship. The integrated approach of remote sensing and GIS study considers terrain parameters like lithology, landforms, soil characters, drainage and slope condition of the terrain along with rainfall. This study has endeavored to establish the relation between these parameters and the groundwater condition. Many of the previous studies were conducted mainly for groundwater exploration, water quality modelling, land use management or similar applications only (Timothy *et al.*, (1994), Darbar *et al.* (1995), Chuvieco (1993)). In contrast, the present study emphasizes the influence of the aforesaid parameters on seasonally dynamic groundwater level fluctuation and quality. The study has adopted a remote sensing and GIS based methodology to comprehend the groundwater environment. Such a methodology, it is believed, could be applied to terrain with similar conditions for better assessment of groundwater parameters. This research study could be further extended for groundwater resources planning and management.

This study has been carried out in Ongur minor river basin, located in the northeastern part of Tamil Nadu, south India (Fig.1.1). This minor basin has been selected on the basis of the presence of contrasting geologic units such as Archaean crystalline rocks and Recent coastal sediments. The methodology adopted for the present study can be applied to similar regions elsewhere.

## 1.4 OBJECTIVES OF THE STUDY

Keeping in view the need for integrating remote sensing and GIS in groundwater environmental studies, the objectives of this study are:

- to delineate potential groundwater zones of the study area, using remote sensing and Geographic Information System (GIS) techniques,
- to study the short-term and long-term seasonal variations in groundwater fluctuation and groundwater quality of Ongur minor river basin using GIS,
- to study the influence of certain terrain parameters such as lithology, landforms, soil, drainage and slope on groundwater environment, and
- to study and establish the relation between groundwater condition and land use practice.

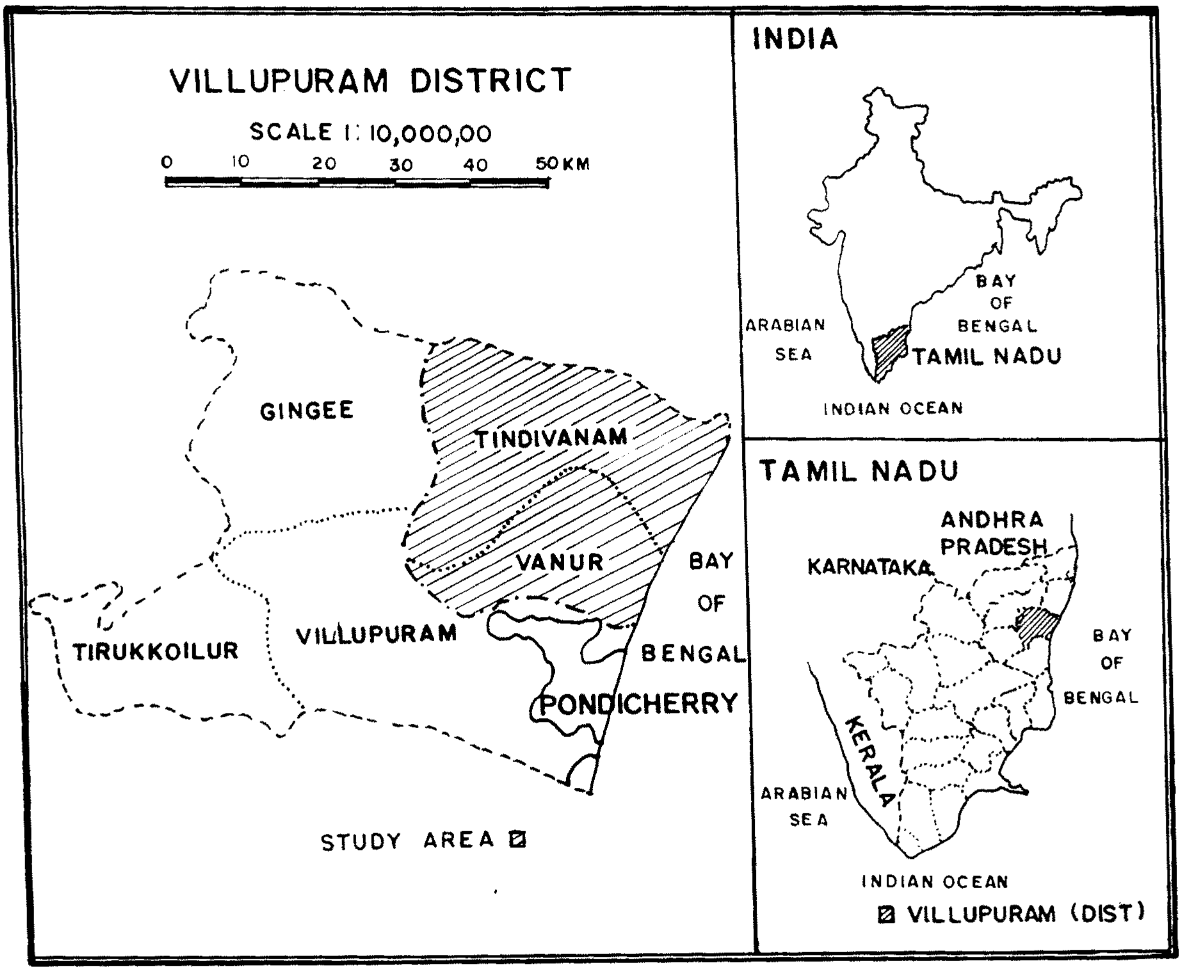


Fig. 1.1 Location map of Ongur minor river basin

## 1.5 STUDY AREA

There are thirty-three minor basins identified by IWS, PWD (Institute for Water Studies, Public Works Department, Tamil Nadu Government). Ongur minor river basin, which is one among them, has been selected as the study area, suiting the requirement for the present research. The area of Ongur minor basin is 1480.08 sq.km and two main rivers, Ongur and Periar, drain the system (Fig. 1.2). Of these, Ongur river is the major river and the smaller Periar river flows south of the former. Both of them are ephemeral in nature and mostly dry during summer .The drainage pattern is mostly east flowing while the western part forms the catchment. The eastern part is bound by the Bay of Bengal where the rivers drain into the sea. The river confluence zone is comprised of Recent sediments.

### 1.5.1 Climate

The Ongur minor basin experiences a tropical climate with a mean annual temperature of 32°C. The hottest spell of the year is during April and May when the temperature soars up to 42°C. The humidity is usually between 70% and 80%. The northeast monsoon contributes a larger share of the total rainfall of the region (October to December) compared to the southwest monsoon (July to September). The average rainfall observed from the records is 950 mm, nearly 60% of which is recorded during the northeast monsoon.

### 1.5.2 Relief

The study area is almost entirely flat except in the northwestern part where undulating terrain and small hillocks are observed. The area comprises rocks from Archaean age to Recent. Granites, gneisses, and charnockites represent the Archaeans. Sandstone, shale, and conglomerates represent the Gondwanas. The unconsolidated sediments of Quaternary period are represented by boulders and alluvium and occur extensively in the coastal area. The coastal plain in this area is comprised of Recent alluvium with sand dunes, encouraging fresh water pockets all along the coastal tract.

### 1.5.3 Drainage

The drainage system of the study area indicates the occurrence of numerous ephemeral streams of first order draining into smaller and bigger tanks. Ongur and Periar are the two principal rivers of the minor basin (Fig. 1.2). Among them, Ongur river starts from the northwestern part of the catchment, and is drained by many first and second order streams before it reaches its confluence. On the other hand, Periar river starts from the western part and drains the central part of the study area and reaches its confluence in the east. Ongur river encounters hard rock terrain during its overland flow whereas the Periar river flows through a large fluvial plain. There are numerous minor streams observed in the basin and they either flow for a short distance or join the higher order streams. They contribute to the surface storage like tanks and ponds in the region and influence the groundwater level of the area. Despite such recharge mechanism, groundwater level in this area is moderate, apart from being contaminated with salt water due to the poor soil condition in certain coastal pockets of the study area. Along the coastal part, two large water bodies, Yedayanthittu lagoon and Kalveli tank, which run parallel to the coastal dunes from north to south, are influenced by tidal effect. A navigable Buckingham Canal runs parallel to the coast connecting the lagoon and the Kalveli tank. Numerous small and big tanks are also located in the study area.

### 1.5.4 Geology

The study area consists of crystalline rock formations in the western part and coastal sedimentary landforms in the east. The oldest rocks occurring in the study area are the crystalline rocks of Archaean age comprising granites, gneisses, charnockites and associated basic and ultra basic intrusives. The granitic rocks are medium to coarse grained and are less massive than the charnockites. The latter are massive and well foliated. The general strike of the foliation in crystalline rocks in this area is NNE-SSW. These rocks are covered by a thick weathered mantle that supports good vegetation.

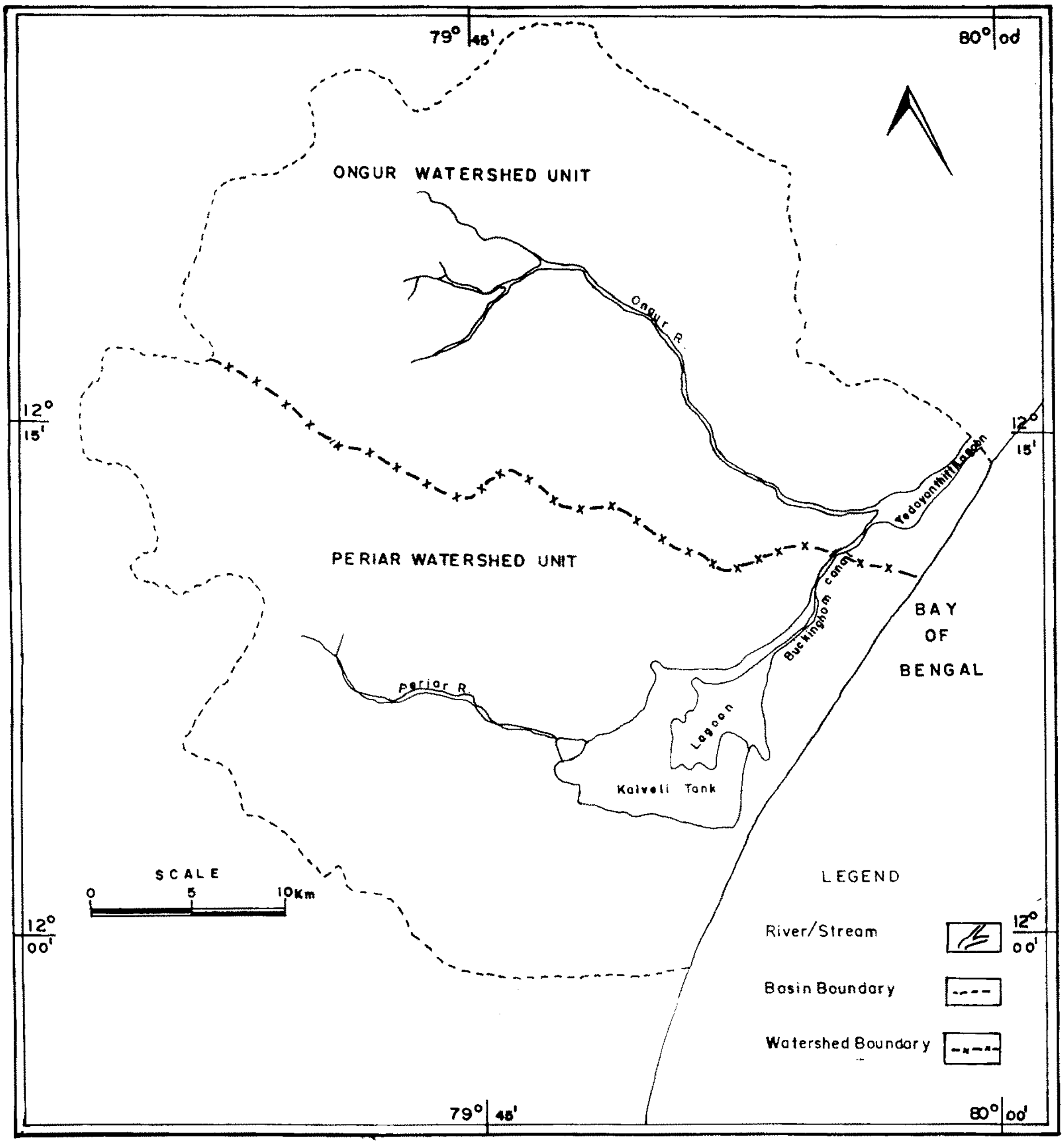


Fig. 1.2 Map showing major drainage of the study area

The Gondwanas of this area are represented by a small patch near Pudupattu. This is represented by shale, thin bedded clays and yellowish, fine grained feldspathic sandstone. The beds dip with a low angle towards east. Due to their susceptibility to weathering, they form a gently rolling topography, and weather into clays.

The Tertiary formations are represented by sand, clay and reddish brown mottled quartz grit. These are exposed in limited areas and are reported to occur below the laterites near Marakkanam. The Gondwanas and Tertiaries are commonly capped by the scoriaceous pisolitic laterites of Quaternary age. Their main occurrence is near Kalveli and also as a few patches along the coast of the study area. The lateritic thickness varies from 1 to 5 m. The eastern part of the study area is observed to have coastal plains. Wind blown deposits of sand in the form of coastal sand dunes occur almost all along the coast. These dunes are a few meters to 1.5 km in width and stretch for a few kilometers. The alluvial plains are observed to be confined along the western and central portions of the study area. The alluvium consists of gravel, pebbles, fine to coarse sand and clay. The thickness of the alluvium increases towards east. The stratigraphic succession is as follows:

| | |
|---|---|
| Quaternary | Recent alluvium, sand, laterites |
| Tertiary | Cuddalore sandstone, clayey sand, shale |
| Gondwana | Feldspathic sandstone and clay |
| Archaean | Hornblende gneissic complex, mica schist charnockite |

### 1.5.5 Soil

The study area consists of mostly poorly sorted and poorly drained clay loamy soil in the east and moderately sorted to well sorted sandy soil in the western catchment part with kankars in few places. The soil in the northwestern part of the catchment is moderately sorted and well drained in nature. The soil condition shows moderate land capability suitable for seasonal cultivation and grazing. The central part shows well drained and well sorted sand and sandy loamy soils that support excellent agricultural activities. The northeastern and southeastern parts show well sorted loamy sand with intermittent presence of clay loamy soil. This soil condition is supportive of good agricultural activities with some limitations. Mostly, plantations of *casuarina spp.* are observed in this part. In the eastern part near Kalveli, Uppu Velur and Chettipalayam, the soil condition is very poor with poorly drained clay soils and marshy lands. The influence of tidal water is evident by the presence of salt tolerant plant species, halophytes, in this area.

### 1.5.6 Land use

The land use of the area may be described as fertile agricultural in the central part, which is mostly tank irrigated and by groundwater through dug wells and bore wells. The northwestern portion of the study area encompasses agricultural lands with intermittent plantation, *casuarina spp.* plantations.

The major land use pattern of the area is identified under agriculture with crop land and fallow land as subclasses. The agricultural activities of the area mostly depend upon the tank irrigation system and dug wells. The socio-economic condition of the basin thrives upon surface water sources like ponds and tanks for irrigation, which are available during the monsoon. The post-monsoon period witnesses a spell of drought when the cultivation depends upon well irrigation. The land supported by tube wells shows sustained irrigation activities throughout the season. The coastal area contains *casuarina spp.* plantations and scrub. Nearly 60% of the area may be classified as cultivated land. The cultivable land includes agriculture, fallow land and plantations. Approximately 25% of the land is observed under lands with or without scrub. The remaining 15% of the land may be categorised as wasteland. These wasteland categories are mostly seen around Yedayanthittu and Kalveli backwaters, and as a small area in the northwestern part of the study area. The Yedayanthittu lagoon, a fishing ground, supports the local population of the surrounding area. The vast area near the lagoon and Kalveli tank is also used for saltpan activities.

## 1.6 SCHEME OF THE THESIS

The present study is organized into eight chapters, from introduction, through discussion to conclusions. The scheme of the study is as follows:

Chapter 1, (this chapter) introduces the problem, giving details on the need, scope, objectives of the study, and description of the study area.

Chapter 2 reviews previous work carried out and attempts not only to justify the necessity for the present study but also propose a suitable method to study groundwater condition of the selected terrain using Remote Sensing and GIS.

Chapter 3 elaborates on data collection, data conversion, data base design, spatial and nonspatial attributes, remote sensing interpretation methods and GIS spatial analysis, flow diagrams on the methodology for each analysis and their justification.

Results of satellite data analysis of Ongur minor river basin to generate various thematic maps like, geology, geomorphology, soil and land use are presented and discussed in chapter 4.

Chapter 5 deals with GIS analysis to delineate groundwater potential zones, to understand the short-term and long-term changes in groundwater fluctuation in the study area and the influence of terrain parameters on such variations.

Chapter 6 deals with the analysis of seasonal variations in groundwater quality and the influence of various terrain parameters namely lithology, landforms, soil, slope, drainage and rainfall on it.

The penultimate chapter discusses the groundwater conditions and land use environment, comparing land use with groundwater potential zones, groundwater level fluctuations and groundwater quality to infer the interrelationships among them.

The eighth and final chapter concludes the study with the findings of the analysis.