CHAPTER I
INTRODUCTION
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1.1 Introduction

Groundwater is used for varieties of purposes, including irrigation, drinking, and manufacturing. Groundwater, a vital natural resource, is the source of large percentage of surface water and is a crucial factor to sustainable development (Papatheodorou, 2010). Understanding exchanges between surface and ground water systems is critical for management of water resources, especially in a watershed where groundwater extractions for irrigation have significant implications. Numerous methods have been discussed in the literature to quantify the interactions between surface and ground waters (Kalbus et al., 2006; Winter, 1999). For such investigations, geological and geomorphological studies of a terrain are important, as they play a major role in controlling its groundwater condition. Three principal factors, namely geologic setting, physiographic features and climate, control the groundwater condition of a terrain and contribute to the better understanding of the groundwater characteristics of a terrain (Adyalkar, 1976). Increasing demand for water has stimulated development of groundwater resources and improvement of techniques for investigating the occurrence and movement of groundwater.

With the advent of remote sensing satellite technology such studies have taken a new dimension. The synoptic view and repetitive coverage provided by remotely sensed image data helped to understand the geological and geomorphological setting of a terrain and their significance in the study of groundwater condition (Rao, 1978). In early 1990s Landsat TM data has supported many such studies (Ravi Prakash and Mishra, 1993) to delineate geomorphological units for groundwater exploration. It is known that geomorphic units in a
given region play a crucial role in controlling groundwater flow (Lafleur, 1999). This was further explained by Winter (1999) emphasizing the importance of streams, lakes, and wetlands on groundwater flow.

Studying the complex nature of aquifer system using spatial analysis of bore hole data, groundwater level, groundwater chemistry and lithological details helped to elucidate the interaction between groundwater and surface water (Giambastiani et al., 2009). Such complex issues could be spatially analysed using integrated remote sensing and GIS approach for groundwater potential studies in a hard rock terrain (Kodituwakku, 1996). Integrated study in GIS environment is the most powerful tool in natural resources assessment and environmental monitoring (Burrough, 1986).

Integrated study of remote sensing and in GIS has paved way to assimilate diverse information from different sources to a common platform to elicit a holistic view of the problem at hand. For example, spatial analysis of geochemical, bore hole and remote sensing information for groundwater development (Gustafsson, 1993), watershed management strategies (Rondal, 1994) groundwater exploration (Timothy, 1994), soil mapping and characterization at various scales (Manchanda et al., 2002), groundwater quality and risk mapping (Renji and Panda, 2008), and artificial recharge zone selection (Balachander et al., 2010) have emphasized the significance of such approach. Most of these studies have stressed on the occurrence of groundwater, their recharge and discharge mechanism and watershed management and not on the intrinsic relationship between various terrain parameters and climate and related seasonal variations in groundwater head - an essential factor, as groundwater condition varies seasonally.
1.2 Need for the present study

The significance of integrated approach has been emphasized by many application studies such as landuse classification (Shih, 1988), integration of remote sensing, Global Positioning System (GPS) and GIS techniques to understand the coastal environment (Welch, 1992), integrated spatial analysis for groundwater prospecting and artificial recharge zone selection. The study on hydrogeological environment is very important as terrain parameters play a crucial role in the control of groundwater level analysis. It is known that there exist a seasonal variation in groundwater level and influence of fluctuation by climate. This is applicable to countries like India where the monsoon is erratic and seasonal variations in groundwater abstraction and recharge are large. This necessitates an integrated spatial analysis for groundwater fluctuation in an area. 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 attempted to carry out such an integrated approach to understand the applicability of remotely sensed satellite data in eliciting terrain details both by image processing analysis and visual interpretation of the selected watershed, Upper Noyyil basin of Coimbatore district, Tamil Nadu, south India. The scope of present study lies in understanding the applicability of image processing of remotely sensed satellite data in bringing out information about the terrain. Moreover, applying image processing techniques such as linear and non-linear filtering, NDVI, normalization, Principal Component Transformation (PCT) and clustering techniques on the selected Landsat TM remote sensing satellite data has brought out
the salient informations of the terrain leading to many logical inferences. Such processed and enhanced satellite image in turn, helped in visual interpretation of the selected study area to delineate various terrain features and in preparing thematic maps such as lithology, landform, soil and other structural details. This, in turn, was converted into a spatial database in Geographic Information System (GIS) environment integrating with other collateral data such as rainfall data, groundwater level data, soil data, bore hole lithology etc.. The spatial data in GIS was analysed to delineate prospective groundwater zones and study the short-term and long-term variations in groundwater level fluctuation. Spatial analysis of comparing the groundwater prospective zones and varying degree of groundwater fluctuation zones with land use practices of the terrain was carried out to understand the existing relationship between groundwater condition and landuse with in the study area.

The integrated approach of remote sensing and GIS study considers terrain parameters like lithology, landforms, soil characters, and slope condition of the terrain along with rainfall. This study has endeavored to establish the relationship between these parameters (terrain and climate) and the groundwater condition. Above all, delineation of landuse categories has helped to understand the significance of groundwater in the development of the Upper Noyyil basin as well as the relationship between groundwater and agricultural activities.

The present study has emphasized the influence of the aforesaid parameters on seasonally dynamic groundwater level fluctuation and deviated from previous studies that were conducted mainly for either groundwater exploration or water quality modeling or land use management or similar applications (Chuvieco (1993; Timothy et al., 1994; Darbar et al. 1995; Ghulam et al., 2004; Balachander et al., 2010) with no illustrations of their existing interrelationship. But, in the present study a remote sensing and GIS based methodology to comprehend the groundwater
environment has been adopted. Such a methodology could be applied to terrain with similar conditions for better assessment of groundwater parameters. Integrated approach attempted in the present study could be further extended to any level from local to regional level incorporating relevant parameters for developing a decision support system for natural resources development activities in a river basin.

1.4 Objectives of the study

The present study was carried out in order to understand the potential and applicability of an integrated approach for the hydrogeological environment of the Noyyil minor river basin, Coimbatore district, Tamilnadu, India. The primary objectives of the study are:

- To identify suitable image processing techniques of the remote sensing satellite data specific to the selected study site to extract information on structural, geomorphological features and soil moisture condition,

- To delineate groundwater prospective zones using GIS overlay analysis and to study the seasonal groundwater fluctuation and their intrinsic relationship with terrain parameters such as lithology, landforms, soil and elevation.

- To study the relationship between spatial pattern of groundwater fluctuation and groundwater prospective zones with existing landuse pattern derived from satellite data.

1.5 Study area and its physiographic setting

The study area, namely Noyyil minor basin and its environs lie in the southwestern part of Tamilnadu state, south India. The selected part of the basin falling in Coimbatore district is situated between the latitudes of 10°53'40" N to 11°18'40" N and longitudes of 76°39'48" E to 77°30'5" E (Figure 1).
Figure 1.1 Location map of the study area

The total area of the watershed covers 2342 sq. km and experiences a sub-tropical climate with a mean annual temperature of 32°C. The hottest spell of the year is during April and May and humidity is usually between 40% and 50%. The northeast monsoon contributes a large share of the total rainfall (October to December) and southwest monsoon (July to September) contributes relatively less. The average annual rainfall is around 710 mm. The Noyyil river, originating from Vellingiri hills, is an ephemeral river, remaining dry for major parts of the year. The Noyyil minor basin is drained by its tributaries Periyar river and Chinnar river. Many lower order streams are also seen but carry water only during the rainy season.
1.5.1 Geology

Geologically the area is predominantly witnessed with metamorphic gneissic rocks along with plutonic rock types of charnockite and granitic rocks of Archaens. The Archaean rock formation comprises metamorphosed hornblende-biotite gneiss, calc gneiss, quartzite etc., apart from charnockite, granitic and pegmatitic rock complexes and limestone occurs at places. They are associated with acid to basic charnockites and pink granites and occasionally the gneisses. Small pockets of valley filled sediments of river alluvium, sand and silt of Quaternary age are also observed in few places. Among these, gneissic complex covers larger extent up to an area of 74.31 percentage of the study area followed by river alluvium, granitic rock unit and charnockitic complex of the study area respectively.

1.5.2 Geomorphology

The study is identified with many significant geomorphic landforms such as pediments, buried pediments of varying thickness from shallow, paleo sand dune, structural hills in the western part, flood plain and valley fills. Landform unit showing pediment is the predominant feature in the study area. The landforms observed in the study have their significance towards groundwater condition of the study area. Buried pediments overlain with varying thickness of weathered material — shallow buried pediment (SBP), moderate buried pediment (MBP) and deep buried pediment (DBP) — encourage varying degrees of groundwater condition in the study area. Duricrust is seen at parts of the upper Noyyil basin. A small patch of valley fill is seen at the foot hill of the structural hill at the catchment part in the western part of the basin. A small area of flood plain is also observed at this part of the study area. The landform features in the study area plays a significant role in the hydrogeological environment of the study area.
1.5.2 Soil

Soil plays an important role in the study area indicating the extent of weathering and suitability for groundwater storage and in turn, their land productivity since they are the resultant product of the combined forces of climate and topography on parent materials. Major soil types include *alfisol* followed by *entisol, vertisol, inceptisol*, and many minor *outcrops* and area under reserve forest. Alfisols are mineral soils relatively low in organic matter with relatively high base saturation containing horizon of clay so that moisture is available to mature a crop. Likewise spatial extent and presence of vertisol indicates clayey soil with deep wide cracks that may hold moisture relatively lesser than alfisol and suitable for particular cropping pattern. Similarly each soil type indicates porosity, permeability (depth), alkalinity, calcareousness and the degree of land suitability to agriculture and leading to certain inferences on the hydrogeological environment of the study area.

1.5.3 Landuse

Landuse of an area reflects not only the soil suitability for particular utilization but also reflects the groundwater condition of the area. It is imperative to learn the landuse pattern of an area to understand the constraints of resource utilization in terms of land and water. Predominant landuse and land cover observed in the study area include forest cover of both deciduous and open scrub forest in the western part, agricultural crop land and fallow land spread along the Noyyil river course and spread throughout the study area indicating high intensity irrigation activities. Plantation is seen mostly at the southern periphery of the study area beside the central part. Plantation indicates certain limitation in terms of soil condition and groundwater condition. Many part of the study also shows wasteland such as land with scrub, land without scrub, stony waste, out crop, gullied and ravenous land and small patches of salt affected land. Landuse
pattern, in turn, indicate the limitation of agricultural activities of a region in terms of land capability and groundwater availability.

1.6 Organization of the thesis

The present study will be organized into seven chapters, from introduction, through discussion to conclusion. First chapter introduces the problem, giving details on the need, scope, objectives of the study, and a brief description of the study area. Second chapter 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 hydrological environment of the selected study site using Remote sensing and GIS. Third chapter will discuss the methodology adopted for generating thematic maps by interpretation of remote sensing data, image processing techniques, flow diagrams and GIS spatial analysis pertaining to the study area. Fourth chapter will discuss the suitability of various image processing techniques pertaining to the study site and fifth one will discuss groundwater prospective zones, seasonal and temporal groundwater fluctuation zone and their relation to terrain parameters. The penultimate sixth chapter will deal with the relationship between the groundwater fluctuation zones and existing land use pattern of the Noyyil minor basin. The final seventh chapter will conclude the study with the findings of the analysis.

1.7 Summary

In the present chapter a brief discussion introducing the general environment of the study and emphasizing the need for such study has been carried out. Also, brief detail on the scope of such study is described amplifying the necessary objectives to carry out such analysis. Present chapter has emphasized the significance of data integration for understanding the hydrogeological environment of the study area extracting information from various sources such as thematic maps from satellite data, field parameters such as bore-hole lithology, soil details,
field data such as rainfall, groundwater level and groundwater quality in GIS environment. With this general introduction about the objective of the study and the study area, a detailed discussion on the previous similar works related to groundwater related is discussed in the next chapter.