CHAPTER-I

River basin is the land area in which a river and its tributaries drain. All the surface water drainage in the area is discharged through the lowest point in the divide and finally empties into the trunk stream of the basin. The All India Soil and Land use Survey Organization divided India into six major hydrological units. They are 1. Indus drainage, 2. Ganga drainage, 3. Brahmaputra drainage, 4. All drainage flowing into Bay of Bengal except the Ganga and Brahmaputra drainage, 5. All drainage flowing into Arabian Sea except the Indus drainage and 6. The Ephemeral drainage in Rajasthan. The Pennar River basin falls in the fourth category drainage.

Land embraces the atmosphere, the soils and the underlying geology, the hydrology and the plants, above and below a specific area of the earth’s surface. It includes the result of the past and present human activities as well as animals within this area, in so far as they exert a significant influence upon the present and future uses of man. The planning and development of land and water resources and adjustment is usually carried out in a successive phases namely land evaluation, socio-economic analysis, classification and programme effectuation. Land and water resources evaluation includes both qualitative and
quantitative assessment. Drainage basin forms the most convenient, as well as most appropriate spatial units for the study of natural resources particularly the basic land and water resources.

Water balance, is an applied climatology deals with water input and water loss in the form of evaporation and evapotranspiration. The major input is precipitation. Based on water input and water loss, the water surplus and water deficit zones can be identified. Cropping pattern is the proportion of area of various crops in a district or group of districts. Cropping pattern includes identification of most efficient crops of the region, which is considered a homogenous of soil and climatic belts. In the present study an attempt is made to describe the geomorphic evolution, evaluation of land and water resources, water balance and cropping pattern of the Pennar River basin.

**STUDY AREA**

The Pennar River basin covers an area about 55,213km² and lies in between 10⁰ and 16⁰ North latitude and 77⁰ and 81⁰ East longitude. The river originates in northern part of Karnataka state in Nandi hills and passes through the Anantapuramu and Cuddapah districts of Rayalaseema region and empties into Bay of Bengal, 30km ENE of Nellore after passing through the Pennar delta of Nellore district. The average annual rainfall of the Pennar basin is 732.11mm. The
average minimum temperature is about $18^\circ$C and the average maximum temperature is about $42^\circ$C. The basin enjoys semiarid, dry sub-humid and wet sub-humid types of climate.

Fig.1.1
OBJECTIVES

The main objectives of the present study are

1. to study the geology of the Pennar River basin,

2. to map and describe the major land systems and landforms of the Pennar basin,

3. to bring out the morphological evolution of the Pennar basin,

4. to evaluate the land resources of the Pennar basin basing on physical characteristics,

5. to evaluate the surface and sub-surface water resources of the Pennar basin,

6. to describe the water balance characteristics and evaluate the water balance of the Pennar basin,

7. to study the land use, irrigation and cropping pattern of the Pennar basin and

8. to describe the water availability days, water availability calendar and crop management of the Pennar basin.

METHODOLOGY
The geological formations of the Pennar basin has been studied from FCC’s on scale 1:250,000 and Geo-coded data on scale 1:50,000. The Geological Survey of India geology maps have also been used to identify and prepare geology map of the Pennar basin. The land systems of the basin are mapped using FCC’s and Geo-coded data based on the concept that similar land systems are reflected in similar variation of texture, soils and land use. The CSIRO method of Australia has been adopted to map the land systems of the basin. The landforms of the basin are mapped through visual interpretation of IRS IB Geo-coded data on scale 1:50,000 and Survey of India topographic sheets on scale 1:50,000. Based on geomorphic processes and agents involved in their formation the landforms have been classified into denudational, fluvio-denudational, fluvial, aeolian and coastal land- forms. The profiles of the Pennar basin at 2 ½ minute’s interval have been taken in the east-west direction and are super-imposed. Based on relative elevation the denudation levels of the basin are interpreted. The slope, relative relief and hypsometric curve of the basin have been brought out. Based on terrain analysis, denudation levels, landforms and their disposition, geomorphic processes and agents involved in the formation of landforms and geological characteristics, the morphological evolution of the basin has been brought out.

The physical characteristics of the Pennar river basin has been studied using SOI topographic sheets on scale 1:250,000 and 1:50,000, and Remote Sensing
data. Based on Survey of India (SOI) toposheet on scale 1:50,000 the relief, slope and drainage of the Pennar river basin have been brought out. The land systems and landforms of the basin are traced from FCC’s on scale 1:250,000 and Geo-coded data on the scale 1:50,000 based on gray tonal variations, texture, slope, alignment, geomorphic processes and agents involved in their formation. The soils of the basin are mapped through visual interpretation of Remote Sensing data. The land use of the Pennar river basin has been mapped through visual interpretation of Geo-coded data for two different seasons. They have been broadly classified into cultivated land (wet), cultivated land (dry), fallow land, current fallow land, cultivable waste land, waste land, water bodies, forest land, forest land under scrubs and bushes and barren lands. The hydro-geomorphology of the Pennar basin has been brought out through visual interpretation of Geo-coded data based on gray tonal variations and hydro-geological characteristics of the basin. Based on relief, slope, drainage, geology, landforms, soils, land use and hydro-geomorphic units of the basin the land capability of the basin has been brought out. About nine classes of land are identified.

The water resources of the Pennar river basin are studied using mean annual rainfall of about fifty five stations. Using the annual precipitation values of 55 stations the annual ground water recharge for each station is worked out. Based on annual
recharge the ground water potential at mandal level has been worked out adopting Rainfall Recharge Method.

The water balance elements of the basin has been worked out for 55 stations taking mean monthly precipitation and mean monthly temperature over a period of 100 years adopting Thornthwaite and Mather (1955) method. The monthly water balance elements namely potential evapotranspiration, actual evapotranspiration, water deficit, water surplus, moisture adequacy, Aridity Index and Moisture Index are worked out for 55 stations using Thornthwaite and Mather (1955) book keeping procedure. The land use, irrigation and cropping pattern at mandal level has been collected from District Statistical Hand Books of Anantapuramu, Chittoor, Cuddapah, Kurnool, Nellore, Prakasham at mandal level and a few talukas of Karnataka state falling in the basin. Adopting appropriate statistical techniques the concentration of land use, irrigation and cropping pattern, intensity, efficiency and combinations are worked out and mapped spatially. The water availability days and calendar has been worked out for 55 stations basing on monthly potential evapotranspiration and monthly actual evapotranspiration values. Finally based on physical characteristics, water resources, water balance and existing land use, irrigation and cropping pattern a few suggestions are made for optimum utilization, conservation and development of land and water resources of the Pennar river basin.

**Review of literature**
Drainage basins are studied by geologists, hydrologists and geographers to assess and evaluate the land and water resources, to study the geo-morphic forms formed in the basin and to bring out evolution of landforms. A few studies are carried out in fluvial geomorphology by Horton (1945) Schumm (1946) Melton (1957), Strahler (1958), Chorley and Morgan (1962), and Georg and Walling (1973). The studies on the terrain analysis are carried out by Went worth (1930), Dury (1951) Strahler (1952), Young (1964), Leopold and Miller (1956), Chorley (1966) and Doorn camp and King (1971), Kharwal (1971) has described about slopes of Himalayan terrain. Dikshit (1976) has studied the terrain forms and characteristics of Konkan basin. Savindra singh (1977), Vaidhyanadhan (1962) Reddy and Reddy (1983) have described varies terrain forms and characteristics of different basins in India.

The research in morphological features has been carried out Strahler (1946), Penck (1953), Wolman and Leopold (1957). Mabbutt (1966) has described about landforms western MacDonnell ranges. Pugh (1966) studied the landforms of low latitudes. Verstappen (1966) has described the role landform classification in Integrated Surveys. Parthsaradhi and Vaidhyanadhan (1974), Prudhivi Raju and Vaidhyanadhan (1977 and 1978), Nageswar Rao and Vaidhyanadhan (1978), Sambasiva Rao and Vaidhyanadhan (1979), and Raghava swamy and Vaidhyanadhan (1980) have mapped the landforms of different parts of India using aerial photographs.
and landsat data. Suryanarayana (1982) has studied the landforms of Dharmapuri district of Tamil Nadu state. An attempt on landform studies of Peninsular India was made by Desphpande (1983).

Horton (1945), Schuman (1956) and Leopold (1962) studied the evolution of landforms of different basins. Ramana Rao and Vaidhyanadhan (1970) identified the erosion surfaces of Eastern Ghats of Andhra Pradesh and Orissa region. Sambasiva Rao et al (1978), Sambasiva Rao and Vaidhyanadhan (1979), Nageswar Rao and Vaidhyanadhan (1979), Sambasiva Rao (1982), Kaladevi (1985) and Sambasiva Rao (2002), have studied the landforms evolution of different basins and deltas of in India. Prudhivi Raju and Vaidhyanadhan (1978 and 1981) have studied the geomorphic features of Chinthapalli area of Eastern Ghats and traced the evolution of Sarada basin. The studies on evolution of landforms of Sarada basin is carried out by Prudhivi Raju (1982) Suryanarayana (1982) has mapped the geomorphology of Dharmapuri district and traced the evolution of different erosion surfaces. Savinder Singh (1977) has brought out the erosion surfaces and geomorphic evolution of Balan basin. Govinda Rajan et al (1980) has made an attempt to study the landform features of the Cumbum Valley. The morphological evolution of Cumbum watershed of Tamil Nadu state covering an area about 2653km² has been studied by Sambasiva Rao and Krishna Reddy (1971). Kaladevi (1985) studied the morphological evolution of Vaigai river basin. The morphological features and evolution of Tambrapani basin has been
carried out by Sambasiva Rao (1982). In India Vaidhyanadhan (1969) is a geologist who has carried out studies on Cuddapah basin and interpreted 60 Survey of India toposheets (SOI) with Illustrations. He has given training to many geologists and geographers to carry out geomorphic mapping in the field using aerial photographs and Remote Sensing Data.

In India the studies on water balance has been carried out by Late Prof. V.P. Subramanyam of Andhra University, Visakhapatnam. He has used Thornthwaite and Mather (1955) water balance technique to carry out studies at basin, district, state and national level. Subramanyam (1956a) studied the climatic types of India according to rational classification of Thornthwaite. Subramanyam (1956) has carried out the water balance of India according to Thornthwaite concept of potential evapotranspiration. The climate of India in relation to distribution of natural vegetation was studied by Subramanyam (1958). Subramanyam etal (1964) has made an attempt to bring out the relation between moisture adequacy and distribution of crops. Subramanyam & Subramanian (1965) has made an attempt to describe the characteristics and occurrence of droughts in dry climatic zones of India. The Subramanyam and Murthy (1968) have studied the eco-climatolgy of Tropics with special reference to India. A study of aridity and droughts of Visakhapatnam was studied by Subramanyam and Sastry (1969). Subramanyam etal (1970) have brought
out the water balance of Godavari river basin. Subramanyam (1982) has prepared a monograph on water balance and its applications with special reference to India.


In India Shafi (1969) has described the methodology and techniques in land use studies, land classification and land capability. Ali-Mohammad (1978) has identified the land suitable for cultivation and land not suitable for cultivation in his book studies in agricultural geography. Land evaluation is the study based on both quantitative and qualitative parameters. The studies on land evaluation based on physical characteristics are carried out by Shafi (1966), Chowdary (1966), Misra etal
The water availability days and water availability calendar studies are carried out by Subramanyam and Umadevi (1981), Sambasiva Rao (1997, 2005 and 2012) and Somanna (2013).

The Agro climatology is an important branch of applied climatology concerned with the optimum utilization of weather and climate as atmospheric resources for maximization of crop yield. As increased food production for the rising world population continues to be a challenging problem. Our dependence on agriculture, animal husbandry and aquaculture appears to be a perpetual feature. Rainfall is the most important among the several metrological factors that control and influence the growth and development of agriculture. Hence crop of plant is called climatological instrument.

The irrigation potential of a region is the water surplus in a season which should be used effectively to eliminate the under irrigated and over irrigated areas. A few of the geographers who have made studies on irrigation are Ghori (1951), David Firman (1955), Dhillon and Shandu (1977) and Pawar and Shinde(1979).

The studies on land use, cropping pattern, crop diversification and crop combination has been widely studied and mapped by various geographers in India. Among them who have prepared detailed land use, crop concentration, crop diversification and crop combinations are Sinha (1954), Goswami (1960), Roy

It was Rajamanickam (1937), who first made an attempt to study the agricultural geography of Madurai district and broadly classified various agricultural regions based on the type of crops that are cultivated within a region. Later Saravanan (1979) has made an attempt to study the importance of geographical factors on distribution of various crops, important crop regions and crop combination of the district. Kalavathi (1983) made an attempt to study the distribution of rainfall, irrigation and cropping pattern of Madurai district.


ORGANISATION OF THE THESIS
1. The first chapter deals with introduction, study area, objectives, methodology, review of literature, source of data and organization of the thesis,

2. The second chapter deals with geology of the Pennar basin,

3. In the third chapter a detailed description of land systems and landforms are described,

4. The fourth chapter speaks about the morphological evolution of the Pennar basin,

5. A study on land resources and its evaluation is discussed in the fifth chapter,

6. The sixth chapter contains the study of surface and sub-surface water resources of the Pennar basin,

7. The water balance characteristics of the Pennar basin are dealt in seventh chapter,

8. The land use, irrigation and cropping pattern at mandal level are described in eight chapter,

9. In the ninth chapter an attempt is made to bring out the water availability days and water availability calendar and describe the crop management of the Pennar basin and

10. The tenth chapter deals with conclusions drawn out of the stud