CHAPTER - I

INTRODUCTION
Water balance is a basic technique in modern climatology and has been gaining importance in various fields of water and agriculture management. With increasing population and decreasing per-capita availability of water, optimum utilization and conservation of water has become vital importance in which water balance plays an important role.

It is now well-established that the water supply to a region is primarily through precipitation and water loss is due to evaporation and evapotranspiration. The wetness and dryness of a place is determined by the relative magnitudes of precipitation and potential evapotranspiration. The major water balance elements are precipitation, potential evapotranspiration, actual evapotranspiration, water deficit, water surplus, moisture adequacy, Aridity Index and Moisture Index.

An all India symposium on water balance and National Development sponsored by University Grants Commission, New Delhi was organized by Department of Meteorology and Oceanography, Andhra University and Indian Meteorological Society Visakhapatnam in Dec-1983 in Andhra University under the directorship of Late Prof.V.P. Subrahmanyam. The symposium covered the aspects water balance in fields of agriculture, hydrology and environmental studies.
A review of the paper indicate that about four paper each are pertaining to water balance, climatic classification, water balance and drought studies and water balance and river basins. About 14 papers are presented and three papers each on water balance and irrigation efficiency and water balance and environmental studies. The proceedings of the symposium would be useful to researcher to think scientifically in the field of water balance.

Cropping pattern means the proportion of the area under various crops at a point of time. A committee constituted by the Government of India in 1960 under the Agricultural Commission determined the cropping pattern according to relative acreage of various crops in a district or a group of districts in an area. Cropping pattern also was determined by spread of crops expressed as a percentage of total area, of important crops. It includes the identification of most efficient crops of the region which is considered as a homogeneous of soils and climatic belt.

Keeping above points in mind the author as selected to study the water balance and cropping pattern of the Rayalaseema region.

STUDY AREA:-

The Rayalaseema region covers in area about 67,293 sq.km. The region covers Anantapur, Chittoor, Kadapa and Kurnool districts. Geographically the district is located in between 12° – 37’ to 16° – 18’ Northern latitudes, and 76° – 50’ to 79° – 59’ Eastern longitudes
(figure 1.1). There are about 234 Revenue mandals and 4395 Revenue villages in Rayalaseema region. The total population of the Rayalaseema region is 1,55,04,738 (2011 Census). The density of population is 230 persons per sq.km. Physically the region is divided to hilly terrain consisting of Nallamalai, Erramallai, Palakonda, Velikonda, Sheshachalam and Thirumala hills, undulating terrain, rolling plains and fluvial plains. The major rivers flowing through Rayalaseema region are Pennar river system with main tributaries like Chitravathi, Papagni, Cheyyuru, Kunderu and Sagileru and other rivers are the Tungabarda, the Krishna, the Hagari, the Handri, the Swarnamuki, the Ponnai, the Bhema, the Bhabuda, the Pincha, the Kalyani, the Arniar, the Pedderu and the Kusastali. The annual rainfall varies from 485 mm in Anantapur district to a maximum 1348 mm in Chittoor district. Climatologically the region experiences dry sub humid type of climate in major parts of the region.
OBJECTIVES:-

The main objectives of the study are

1. to study the distribution of monthly, seasonal and annual rainfall, rainfall intensity, rainfall variability and rainfall ratio,
2. to study the distribution of monthly, seasonal and annual water balance elements like potential evapotranspiration (PE), actual evapotranspiration (AE), water deficit (WD), water surplus (WS), moisture adequacy (Ima), Aridity Index (Ia), and Moisture Index (Im). Based on the values of Moisture Index and Aridity Index the Climatic Classification of the Rayalaseema region is described,
3. to describe the land use concentration and land use efficiency of the Rayalaseema region at mandal level,
4. to analyze and map the various sources of irrigation of the Rayalaseema region at mandal level,
5. to study the cropping pattern, intensity of cropping pattern, crop diversification and crop combination of the Rayalaseema region at mandal level,
6. to workout the water availability days and calendar in different periods of the 47 stations of the Rayalaseema region and describe the crop management of the Rayalaseema region and
7. to bring at the relationship between the water balance elements, land use efficiency, intensity of irrigation and cropping pattern
and suggest appropriate crops suitable to different agro-climatic regions of the Rayalaseema region.

**METHODOLOGY:-**

1. The data pertaining to monthly rainfall over period of 100 years has been collected for 47 stations of the Rayalaseema region. The rainfall data is analyzed to describe the rainfall intensity, rainfall variability and rainfall ratio.

2. The temperature data over period of 50 years has been collected for the Rayalaseema region for available stations. The data is analyzed to study the thermal efficiency. Based on book keeping procedure of Thornthwaite and Mather (1955) method the monthly potential evapotranspiration, actual evapotranspiration, water deficit and water surplus are worked out. Based on the values of PE, AE and WD the moisture adequacy, Aridity Index and Moisture Index are worked out and mapped on monthly, seasonal, annual basis of the Rayalaseema region. The water balance of the Rayalaseema region is worked out.

3. The land use data at mandal level for the year 2009-2010 has been collected for the four districts of the Rayalaseema region at mandal level. It is used to analyze the concentration of different land uses of the Rayalaseema region and worked out the land use efficiency at mandal level taking positive variables
like net sown area, area sown more than once, total cropped area, intensity cropping pattern and intensity of irrigation.

4. The irrigation data at mandal level has been collected for the year 2009-2010 to analyze the irrigation, concentration and intensity.

5. The cropping pattern data for the year 2009-2010 has been collected at mandal level and analyzed to study the crop concentration, crop diversification, intensity of cropping pattern and crop combination. Finally based on water balance elements land use, irrigation and cropping pattern, the crop suitability map of the Rayalaseema region is prepared.

6. The water availability days and calendar of the Rayalaseema region is worked out based on the monthly values of PE and AE. If PE=AE, then it is called humid period. If the value of AE is half of the PE value or more than it is called as wet period. If the value of AE is $1/4^{th}$ of the PE value or more than, it is considered as moderately dry period and if the value of AE is $1/8^{th}$ of the PE or more than, it is termed as dry period. Based on the above said classification the water balance availability days and calendar are worked out for the Rayalaseema region.

The Rayalaseema region comprises four districts. They are Anantapur, Chittoor, Kadapa and Kurnool. The profile of each district is given briefly.
1. ANANTAPUR

Anantapur district was formed in the year 1882 having been separated from Bellary district. Later on, it was expended with the addition of revenue mandals of Kadiri, Mudigubba, Nallamada, Nambulipulikunta, Talupula, Nallachervu, O.D.Cheruvu, Tanakal, Amadagur and Gandlapenta from Kadapa district in the year 1910. During the year 1956, the present Revenue mandals of Rayadurgam, D.Hirehal, Kanekal, Bommanahal and Gummagatta of Bellary district were added to Anantapur district. The district has been divided into 3 Revenue divisions consisting of 63 Revenue mandals.

BOUNDARIES AND TOPOGRAPHY:

Anantapur district lies between 13° 40’ – 15° 15’ Northern Latitude and 76° 50’ and 78° 30’ Eastern Longitude. It is bounded by Bellary, Kurnool district on the North. Kadapa and Kolar district of Karnataka on South East and North respectively. The district is roughly oblong in shape, the longer side running north to south with a portion of Chitradurg district of Karnataka state intruding into it from west between Kundurpi and Amarapuram mandals.

The district may be divided into 3 natural divisions. They are 1. Northern mandal of Rayadurgam, Kanekal, Beluguppa, Gooty, Guntakal, Vajrakurur, Urvakonda, Vidapanakal, Yadiki, Tadipatri, Putlur, and Yellanur containing lager areas of black cotton soils 2. Kalyanadurgam, Kambadur, Settur, Brahmasamudram, Ramagiri,
Kanaganapalli, Cennekothapalle, Dharmavaram, Bathalapalle, Tadimarri, Mudigubba, Anantapur, Kudair, Pamidi and Peddavadugur in the center which are mainly made up of arid treeless, expense of poor red soils, 3. High level land of Penukonda, Roddam, Somandepalle, Hindupur, Lepakshi, Chilamathur, Madakasira, Rolla, Gudibanda, and Agali which connects with Mysore plateau at higher elevation of the rest of the district. This part has average sandy red soils of normal productivity.

FORESTS:

The forests in the Anantapur district are thin and scanty. The Muchukota hills about 35kms. In length, run from North of Gooty town upto extreme Southern corner of Tadipatri and Yadiki mandals. Another line of hills starts from west of Gooty mandal and run 80kms. Called by name Nagasamudram hills. The Mallappakonda range begins at Dharmavaram and runs into Karnataka state.

The Penukonda range which starts in the south of Dharmavaram through Penukonda and Hindupur proceeds to Karnataka state. In Madakasira, the hills divides Rolla and Agali mandals into southern and northern portions.

There are numerous isolated peaks and rocky clusters which are devoid of any vegetation. The height of some of these hill ranges are given below:
North of Bukkapatnam  -- 915.24 meters above MSL

Penukonda  -- 924.38 meters above MSL

Kundurpi Durgam  -- 913.41 meters above MSL

Madakasira  -- 895.12 meters above MSL

**RIVERS:**

**PENNAR**

The important river in the district is Pennar. It has its origin in the Nandi hills of Karnataka state where it is called “UTTARA PINAKINI” and enters this district in the extreme south of Hindupur mandal and flows through Parigi, Roddam, Ramagiri, Kambadur, Kalyanadurgam, Beluguppa, Uravakonda, Vajrakarur, Pamidi, Peddavadugur, Peddapappur, and Tadipatri mandals and finally enters Kadapa district.

**JAYAMANGALA**

River which has its origin in Karnataka state enters this district in Parigi mandal and joins Pennar River at Sangameswarapalli of Parigi mandal.

**CHITRAVATHI**

Another significance river in the district is “CHITRAVATHI”. Its origin is in Karnataka state. This river enters the district near
Kodikonda village of Chilamathur mandal and flows north over rocky and hilly uplands of Gorantla, Puttaparthi, Bukkapatnam, Kothacheruvu, Cennekothapalle, Dharmavaram, Bathalapalle, Tadimarri, and Yellanur mandals and falls into Pennar river at Gandikota in Kadapa district.

**VEDAVATHI or HAGARI**

This river is also an important one in the district and has its origin in Karnataka state and flows through Gummagatta, Brahmasamudram, Beluguppa, Kanekal and D.Hirehal mandals and enters Bellary district of Karnataka state. Bhairavavithippa project constructed on this river.

A part from these streams like KUSHAVATHI in Chilamathur mandal, SWARNAMUKHI in Agali mandal, MADDILERU in Nallamada, Kadirir and Mudigubba mandals, PANDAMERU in Kanaganapalli, Raptadu, Anantapur, B.K.Samudram and Singanamala mandals, PAPAGNI in Tanakal mandal are important water supply sources to various large and medium irrigation tanks in the district.

RAINFALL AND CLIMATE:

The district of Anantapur has a fairly good elevation which provides the district with tolerable climate throughout the year. It has a gradual fall from the south north towards the valley of the Pennar in Peddavadugur, Peddapappur and Tadipatri Mandal. There is a gradual rise in Hindupur, Parigi, Lepakshi, Chilamathur, Agali, Rolla and Madakasira Mandal in the south to join the Karnataka Plateau where the average elevation is about 600 meters is above the mean sea level. It is about 335 meters at Anantapur and the lowest 274 meters is at Tadipatri. The geographical positions of the Peninsula render it, the driest part of the state and hence, agriculture conditions are more often precarious. Monsoons also evade this part due to its unfortunate location. Being far from the East coast, it doest not enjoy the full benefits of northeast monsoons and being cut off by the high Western Ghats, the southwest monsoon is also prevented from penetrating and punching the thirst of these parched soils. It is therefore seen; the district is deprived of both the monsoons and subjected to droughts due to bad seasons. The normal rainfall of the district is 553.0 mm by which it secures least rainfall when compared to Rayalaseema and other parts of Andhra Pradesh. The normal rainfall of the southwest monsoon period is 338.0 mm. Which forms about 61.2% of the total rainfall for the year. The failure of the rains in this southwest monsoon period of June to September will lead the district to drought by failure of crops. The rainfall of northeast
monsoon period is 156.0 mm only, which forms 28.3% mm of the total rainfall of from October to December. The other months are almost dry. The March, April and May are warm months when the normal daily maximum temperature ranges between 31.7°C to 38.9°C. The November, December and January are cooler months when the temperature falls about 14.5°C. The Hindupur, Parigi, Lepakshi, Chilamathur, Agali, Rolla and Madakasira Mandals being at high elevation are more cooler than the rest mandals in the District.

SOILS:

The soils in Anantapur District are predominantly red except Kanekal, Bommanahal, Vidapanakal, Uravakonda, Vajrakarur, Guntakal, Gooty, Pamidi, Peddavadugur, Yadiki, Tadipatri, Yellanur, Peddapappur and Putlur mandals. In these Mandals red and black soils occur almost in equal proportion. Thus 76% red soils, 24% are black soils.

POPULATION:

There are 929 inhabited villages, out of 964 total Revenue villages of the District. The number of villages in size group of 500 to 1999 forms 36.71% of the total inhabited villages. The size group of 2000 to 4999 forms 38.64% and the size group of 5000 to 9999 forms 12.81% only. Out of total villages, 84 villages of total inhabited villages are having population less than 500. There are 26 villages with more than 10000 population excluding towns. The density of
population of the district is 190 per km² against (277) of the state. The population of rural and urban to the total population of the District works out to be 75% and 25% in 2001 Census as against 76.5% and 23.5% of 1991 Census. The working force in the total population of District forms 48.83% as per 2001 Census out of which 26% are in the Agriculture sector.

LAND UTILISITION:

The total geographical area of the district is 19.13 lakh hectares. The land utilization pattern as available in the district reveals that the net area sown is 10.83 lakh hectares. The total cropped area is 11.54 lakh hectares. The area sown more than once is 0.71 lakh hectares.

The cultivated area of the district is 11.54 lakh hectares. Out of which 9.98 lakh hectares is under Kharif and 1.55 lakh hectares, is under Rabi season during year 2008 – 2009. The district occupies the lowest position in respect of irrigation facilities with only 12.62% of the gross cropped area during 2008-2009. Out of the gross irrigated area of 1.46 lakh hectares during 2008-2009 canals accounted for 14.66%, tanks 6.12%, tube wells 70.87%, wells 6.77% and other sources 1.58%. All the principal sources except canals are non-precarious.
NATURAL RESOURCES:

FOREST:

The district is not rich in the forest wealth. The name ‘forest’ in Anantapur district does not indicate any dense tree population with thick foliage of variform of pastures. The forests area is covered with scrubs and bushes.

MINERAL RESOURCES:

GOLD: At Ramagiri village in Ramagiri mandal, gold is found to occur in the cholite schit’s and phyasmine along with western part of Dharwar schit’s belt in the district. The place extends over a length of 14 km. Exploratory mining in the area is pruned about 467 meters of ore shoots with an average width of 100 cms tone. Mining operations are expected to be conducted by Bharat Gold Mines Limited.

DIAMONDS: Diamonds are known to be available near Vajrakarur. They mainly occur in pipe rocks.

ASBESTOS: Barites of high grade limestone, iron ore and steatite are the minerals occurring in the district. There are however no large sized minerals occurring in the district. There are 2 large scale Cement factories in Tadipatri mandal and producing lakhs tones of cement in private sector.
2. CHITTOOR DISTRICT:

Chittoor district was constituted on 1st April, 1911, comprising the taluks of Chittoor, Palamaneru and Chandragiri transferred from North Arcot district of Tamilnadu, Madanapalli and Vayalpadu taluks from Kadapa district and Ex-Zamindari areas of Punganuru, Srikalahasthi, Puttur and old Karvatinagar Estate by 1.12.1928, Kangundhi taluk of North Arcot district with the exception of 22 villages was transferred to Palamaneru taluk and in 1950 under the province and states (Absorption of Enclaves) Order, 8 villages of Mysore state were transferred to Palamaneru taluk. The next major change in Jurisdiction of the district took place on 1st April 1960 as a result of Pataskar Award. Consequent on the re-organization of the state on linguistic basis, a major portion of Thiruthani taluk was transferred to Chengalpattu district of Tamilnadu. Instead one taluk known as Satyavedu comprising 76 villages of Tiruvallur taluk, 72 villages of Penneri taluk both of Chengalpattu District of Tamilnadu and 17 villages of Puttur taluk, 19 villages of Thiruthani taluk was constituted and added to Chittoor district. Also from the same date, the sub taluks of Kuppam and Bangarupalem were constituted transferring 220 villages from Palamaneru taluk and 3 villages from Krishnagiri taluk of Salem district of Tamilnadu to form Kuppam sub-taluk and 145 villages from Chittoor taluk to form Bangarupalem sub-taluk. Subsequently Kuppam and Bangarupalem were made full-fledged taluks. The above 11 taluks of the district were re-organized
in to 15 taluks and 20 Panchayath Samithis. Again the above 15 taluks of the district were re-organized in to 66 Revenue Mandals as per G.O, Ms.No.556- Revenue (Mandal -2) Department., Date :22.05.1985. Subsequently 65 members Praja Parishads were formed.

BOUNDARIES & TOPOGRAPHY

The District is bound on the north by Anantapur and Kadapa district on east by Nellore district and Chengalpattu district of Tamilnadu. On the south by North Arcot district of Tamil Nadu and on the west by Tamil Nadu and Karnataka states. The district covers an extent of 15,152 Sq.Kms. It is divided into 3 revenue divisions viz., Chittoor, Tirupathi and Madanapalli. It is situated between 12° -37′′, 14°-8′′ of North latitude and 78 ° -33′′ to 79 ° - 55′′ of the Eastern Longitude.

The district can be divided in to two natural divisions:

1. The mountainous plateau on the west comprising the 31 of Madanapalli Division
2. The plains on the East comprising the Mandals of Puttur, Narayanavanam, Vadamalapeta, Ramachandrapuram, Karvatinagar, Vedurukuppam, Srirangarajapuram, Palasamudram, Nagari, Nindra, Vijayapuram, Pichatur, Nagalapuram, Satyavedu, Varadaiahpalem, Buchinaidu Kandriga, K.V.B.Puram, Thottambedu, Srikalahasthi and Yerpedu. The Mandals viz., Chittoor, Gangadharanellor, Puthalapattu,
Penumur, Gudipala, Yaddamarri, Thavanampalle and Irala stand almost as dividing line between the two natural divisions of the district. The eastern Ghats are predominant in the western region and they gradually bend towards the scared gills of Tirupathi, passing through Chandragiri erst-while taluk and entering in to Nellore district. The general elevation of the mountainous part of the district is 762 meters above mean sea level.

**CLIMATE:**

The climate of the district is dry and healthy. The upland mandals consist of 31 mandals in Madanapalli Division are comparatively cooler than the eastern mandals except Chittoor where the climate is moderate.

**RAINFALL:**

The district has the benefit of receiving rainfall during both the south west and northeast monsoon periods. While the normal rainfall of the district for the southwest monsoon period is 438.00 mm that for northeast monsoon period is 3965.00 mm. The rainfall received during the winter period and hot weather period is negligible and their respective normal being 12.0 mm and 88.0 mm. The annual normal rainfall of the district is 934.0 mm.

The rainfall received form the southwest monsoon is more copious compared to northeast monsoon in the western mandals and
in the Central part of the district, where as the rainfall received from
northeast monsoon is comparatively copious in the eastern mandals
of the district.

**RIVERS:**

The rivers flowing in the district are non-perennial in nature in
that they remain dry for a major part of the year. Of these rivers
Ponnai which is tributary of river Palar rises in erst-while Chittoor
taluk and flowing towards the south, joins the Palar in Tamil Nadu.
The Swarnamukhi another important river which rises in the eastern
Ghats in erst-while Chandragiri taluk has its course through the
mandals of erst-while Chandragiri taluk and part of erst-while
Srikalahasthi taluk and ultimately flows into Nellore district. Other
such important rivers to the district are the Kusastali, the Bheema,
Bhuda, the Pincha, the Kalyani, there Araniyar and the Peddery
which flow in different mandals of the district. Besides the above
rivers, there are a number of small hilly streams flowing in the
district.

**SOILS:**

The major portion of the district is covered by red soils with
portions of alluvial soil in Chittoor and Bangarupalem. According to
an assessment made on the basis of village records, 57% of the soils of
the district are red loamy and 34% Red Sandy. The remaining 9% is
covered by black clay (3%) black loamy (2%) black Sandy (1%) and red clay (3%).

MINERAL:

The District is not rich in mineral wealth, Steatite is the only mineral mined in Puttur and Gangadharanellor areas of the district. However, the occurrence of gold, iron and red moulding sand are also noticed in certain parts of the district. In Bisanatham area of Kuppam, the auriferous veins are 22% wide and carry an average gold content of 5.190-wts of gold per tonne. Iron ore occurred in intimate association with hematite in Vayalpadu, Srikalahasthi and Puttur.

IRRIGATION:

There are five major irrigation projects in the district. They are Telugu Ganga Project, Galeru Nagari Sujala Sravanthi (GNSS), Handri –Neeva Sujala Sravanthi (HNSS) and S.S.Canal with an ayacut of 1,48,131 hectares and the estimate cost of these projects are 2698.12 cores.

There are 8 medium irrigation projects in the district. They are Swarnamukhi Ayacut, Araniyar, Mallimadugu, Kalangi, Bahuda, Siddalagandi Project, Krishnapuram Reservoir and Padderu Project. The total registered ayacut under the eight projects is 15310 Hectares.
There are 7512 minor irrigation tanks with total ayacut of 54,336.14 hectares. The district occupies a pride of place in the number of irrigation wells totaling to 1, 16,239 in number.

3. KADAPA DISTRICT

HISTORICAL BACK GROUND AND FORMATION:

Kadapa district was connected with Mouryans in BC era and Sathavahanas in 3rd century AD. However, as the name suggests, it is connected with lord Venkateswara, Kadapa, being the 1st place the pilgrims have to visit lord Venkateswara before going to Tirupathi to have darshan of lord Venkateswara. The district was first formed in early 19th century during the British rule.

BOUNDARIES AND TOPOGRAPHY:

The Kadapa district is surrounded by Kurnool district on the north, Chittoor district on the south Nellore on the east and Anantapur on the west between the 13°- 43’ and 15°-14’ northern Latitudes and 77°-55’ and 79°-29’ of the eastern Longitude.

DEMOGRAPHIC PARTICULARS:

The total geographical area of the district is 15,359 sq.kms. There are 3 revenue divisions, 51 mandals, 804 gram panchayats, 965 revenue villages and 4954 habitations. Kadapa lies as per 2001 census, the population of the district is 26, 01,797 of which the rural
population is 2,014,044 and the urban population is 5,87,753. The density of population in the district is 169 per sq.km.

**LAND UTILIZATION:**

The total geographical area of Kadapa district is 15,35,900 hectares. which constitutes an extent of forest of 5,00,295 hectares, barren & uncultivated land of 2,22,538 hectares, land put to non-agricultural uses of 1,81,015 hectares, cultivable waste of 48,481 hectares, permanent pastures and other grazing lands of 9,674 hectares, land under miscellaneous tree crops & groves not included in net area sown of 6,858 hectares, current fallows of 92,835 hectares, other fallow lands of 68,928 hectares and net area sown of 4,05,276 hectares during the year 2008-09.

**NATURAL RESOURCES:**

Kadapa is also considered to be one of the district endowed with rich history, of minerals flora & fauna. Hyder Ali, Tippusulthan, Sivaji, Krishnadevaraya and Pratapa Rudra are some of the names associated with the History of tract. The district is blessed with a series of beautiful valleys through which Papagni, Cheyyeru Rivers flow. The river Penna is the most important river flowing right through the district whose legend is incorporated asesanam (inscription) at Gandikota. The Sheshachalam range of hills passes through this district and is crowned ultimately with the holy shrine of Thirumala in Chittoor district. Thus Kadapa tract is associated
with such holy rivers and hills have been considered as a holy land. This tract has also been identified as the forest of Dandaka through which the god king Sreerama and his consort Seetha wandered during their 14 years of exile.

**Developmental Activities:-**

1. **Agriculture:-** The majority of the people here are depend on agriculture only. The major crops in the district are paddy, groundnut, sunflower, cotton, betel leaves and horticultural crops like mango, papaya, banana, lemon and oranges. The gross cropped area in the district is 5, 02,402 hectares. Out of this gross irrigated area is 1, 57,767 hectares.

2. **Irrigation:-** The major source of Irrigation is under K.C.canal. There is a major Irrigation Project on Penna at Mylavaram. Pincha Project, Lower Sagileru Project, Upper Sagileru Project, Annamaya Project, Brahma Sagar Project and Pulivendula Branch Canal are medium Irrigation Projects in the district.

3. **Education:-** The district has been served by 3291 primary schools, 531 upper primary schools, 711 high schools, 137 junior colleges, 42 degree colleges and Yogi Vemana University offering P.G. courses for general education. For Technical education the district has 9 polytechnics and 20 engineering colleges, Rajeev Gandhi Institute of Medical sciences, 1 Dental college, 1 Homoeopathic Medical College, 1 Veterinary College and 1 IIIT centre at Rajeev Knowledge valley.
4. **Industries:-** The district has 6 large scale and medium scale Industries with an investment of Rs. 782.92 Crore providing employees 1175 The district has 78 small scale units functioning and employing 1077 persons with an investment of Rs. 3175.58 lakhs.

5. **Transport and Communications:-** The district is served by broad gauge railway line running 190.81 kms. There are 24 railway stations covering 13 mandals. The district has 831.83 Kms highway. All the 51 mandals head quarters are served by pucca roads with bus facilities and the A.P state High Way Project links Kadapa to Renigunta & Tirupathi.

6. **Others:-**

   a) **Soil:-** The soils in the district are of two types, i.e., red ferruginous and black soils, black clay is the most superior soil in the district, which occupies 23.7% area in the district.

   b) **Minerals:-** The district is rich in minerals value. The major minerals in the district are barites, lime stone and asbestos. Apart from major minerals, minor minerals are napa slabs, road metal, building stone, marble, mosaic chips and redmatti are also in the District.

   c) **Power:-** The establishment of Muddanur Thermal Power Station installed with capacity of 420 M.K.W. has become one of the major power generation in the state, generating 6741.60 million K.W.
4. KURNOOL DISTRICT:

LOCATION AND COMPOSITION:-

This district derives its name from its chief town Kurnool the capital of former Nawabs, Capital of Andhra Pradesh State from 1st October 1953 to 1st November, 1956 and at present the headquarters of the district. The name Kurnool is said to been derived form “Kandanavolu”.

Kurnool district lies between the northern latitudes of $14^0 - 54'$ and $16^0 - 18'$ and eastern longitudes of $76^0 - 58'$ and $79^0 - 34'$ northern latitudes. The altitude of the district varies from 100 to 900 meters above the mean sea level. This district is bounded on the north by Tungabhadra and Krishna rivers as well as Mahabubnagar district, on the south by Kadapa and Anantapur districts on the west by the Bellary district of Karnataka state and on the east by Prakasam district. The district ranks 10 in population with 35,29,494 people accounting for 4.63 % of the total population of the state as per 2001 Census, while in area it occupies the 3rd place with 17658 Sq. Kms., which account for 6.41 % of the total area of the state.

At present Kurnool district comprise 3 Revenue Divisions, 54 Revenue Mandals 53 Mandal Parishads, One Municipal Corporation, 4 Municipalities, 898 Gram Panchayats, 926 Revenue Villages and 647 hamlet villages.
PHYSIOGRAPHY:-

Nallamalai and Erramallai are the two important mountain ranges in the district running in parallel from north to south. The Erramallai divide the district into two well defined tracts from east to west. Between Erramallai and Nallamalai lies the eastern part of the district comprises Nandikotkur, Pagidyala, Kothapalle, Pamulapadu, Atmakur, Velugode, J.Bunglow, Midthur, BandiAtmakur, Gadivemula, Nandyal, Mahanandi, Panyam, Banaganapalle, Owk, Koilakuntla, Rudravaram and Chagalamarri Mandals. This tract is crossed by the crest of Krishna and Pennar, watershed at the north part of the Pagidyala mandal at about 305 meters above the sea level. From this height the ground slopes to the south along the river Kundu till it traverses into Pennar valley. Major part of its tract is predominantly black cotton soils.

The western tract comprises Pathikonda, Tuggali, Maddikera, Devanakonda, Gonegandla, Dhone, Peapally, Veldurthi, Bethamcherla, Krishnagiri, Kurnool, Orvakal, Kallur, Kodumur, C.Belagal, Gudur, Yemmiganur, Nandavaram, Mantralayam, Adoni, Peddakadubur, Kosigi, Kowthalam, Alur, Aspari, Holagunda, Halaharvi and Chippagiri Mandals. The terrain here slopes from south to north and it is drained by the river Hundri which joins the river Tungabhadra at Kurnool. The soils in the north western observed parts by the river Hundri are black cotton while the south eastern parts are predominantly pure red soils.
CLIMATE:-

The Climate of the district is normally good and healthy. January, February and March months are usually pleasant with moderate winds from south-east. April and May are hottest months of the year, during these months the wind shifts to southwest with increase in force and brings welcome showers by the end of May. During the succeeding four months the wind blows from western side in major parts of the district and brings fair quantum of rainfall. By the end of September the wind is light and pleasant forecasting the onset of northeast monsoon. In November and December the weather is fine. The rainfall is rare and wind is light with occurrence of heavy dew. The district normal rainfall of the year is 670 mm.

RIVER:-

The principal rivers flowing in the district are the Tungabhadra (and its tributary is Hundri) the Krishna and the Kunderu.

The Tungabhadra rises in the Western Ghats and after forming part of northern boundary for some distance separates Kurnool from the Telangana area flows in an eastern direction receives Hundri and falls into the Krishna river at Kundali Sangam after winding northwards.

The Hundri, a tributary of Tungabhadra rises in the fields of Maddikera in Maddikera mandal receives a stream from Erramallai
at Laddagiri in Kodumur mandal and joins Thungabhadra at Kurnool. It drains much of Maddikera, Pathikonda Devanakonda, Gonegandla, Kodumur and Kallur mandals. This is a turbid stream with sudden raise and fall. The Kunderu also called Kumudvathi rises on the western side of Erramallai winds its way into Kunderu valley and flows in a southern direction collecting drainage all along its course from either side. It flows through Orvakal, Midthur, Gadvemula, Nandyal, Gospadu, Koilakuntla, Dornipadu and Chagalamarri mandals and there enters Kadapa District.

**FLORA FOREST AND FAUNA FOREST:-**

The forestic composition of the district stands in direct relation to that climate and edaphic conditions and the biotic influence in various locations.

Broadly speaking the eastern portion of the district bears better vegetation while the western of especially the northwestern portion comprising of Adoni, Peddakadubur, Alur, Aspari, Chippagiri, Halaharvi, Holagunda, Koilakuntla, Sanjamala, Owk, Pathikonda, Devanakonda, Krishnagiri, Veldurthi, Kodumur, and Kallur mandals presents a desolate appearance and the vegetation that exists is confined mostly to small pockets of reserve forests.

The total area under forests is 3,40,669 hectares. Accounting for about 19.29 percent of a total geographical area of the district. The major parts of the forest area are confined mainly to the Nallamalai
including its extensions, the Erramallai and a part of the Velikondas. The forests covering the Erramallai and Velikondas are of interior type Bamboo with timber species occurs fairly over extensive areas in the district. Tamarind and Beedi leaves are the important minor forest produce of the district.

Wild animals are found in plenty in Nallamalas and Erramallai hills which afford an ideal abide for wild life tiger, panthers bears, jackals, hyenas wild bears, foxes, spotted dears, sambers, black bucks, nelgais, wild sheep etc., are found in these forests. In order to preserve the wild animals, forest of the northern part of Nallamalas covering an area of about 46,815 hectares has been brought under the Nagarjuna Sagar – Srisailam Wild Life Sanctuary.

Partridges, peacocks, red jungle foul, green pigeon, quails are the chief game birds found in the forests. The great Indian Bustard (Batta Meka) an endangered bird species is found near Rollapadu village of Midthur mandal and an area of about 1,600 hectares around Rollapadu village has been declared as protected area for propagation of this species.

In the year 1983 Tiger project has been started near Srisailam covering 3,568 Sq. Km. of Nallamalas forest with 64 Tigers and 78 Panthers population as per 2003 Census.
LAND AND LAND USE:-

The total Geographical area of the district is 17.658 lakh hectares. During the year 2008-09 the area covered by forest is 3.406 lakh hectares which forms 19.3% to the total geographical area. The net area sown of 8.89 lakh hectares, forming 50.35% to the total geographical area. The total cropped area in the district is 10.35 lakhs hectares. The area sown more than once during the year is 1.04 lakh hectares.

IRRIGATION:-

The gross cropped area of the district is 10.35 lakh hectares, of which 2.53 lakh hectares are irrigated through canals, tanks, wells and other sources during 2008-09.

POWER:-

The district receives its power supply from Tungabhadra and Hampi Hydro Electric Power Stations.

Srisailam Hydro-Electric Power Project is constructed across the river Krishna at a distance of 3 Km from famous Srisailam Temple. The total cost of Project was Rs. 433 Crores. There are seven hydro generators of 110 M.W. Capacity each and electricity produced during 2008-09 was 1811.398 Million KWH.
MINERAL RESOURCES:

Kurnool District possesses enormous deposits of lime – stone suitable for cement manufacture, apart from this, the important minerals of economic value in the district are barites, yellow shale, white shale, steatite etc.,

Lime-Stone occurs in Kallur, Orvakal, Dhone, Peapally, Panyam, Banaganapalle, Owk, Gadivemula and Kolimigundla mandals with an annual exploitation of 74.77 lakh million tons. The annual out turn of the other minerals in the district is 285.62 lakh million tons during 2008-09.

REVIEW OF LITARATURE:

Water balance is the study of water input in the form of precipitation and water loss in the form of potential evapotranspiration. The wetness and dryness of the region is the determined by magnitudes of the balance of these two elements namely precipitation and potential evapotranspiration of all the climatic elements rainfall is an important parameter which controls the total cropped area under rainfed condition. The timely fall of the rainfall is important for crop phenology. Moisture is an important factor for crop growth. Rainfall is measured through a good network of raingauge stations. The potential evapotranspiration is expressed as the expotential function of the mean monthly temperature. When rainfall and potential evapotranspiration are exactly equal in amount
there is neither deficiency of moisture nor surplus of wasteful run-off. When precipitation is greater than potential evapotranspiration the humid climate prevails. When potential evapotranspiration is more than precipitation then the arid climate results. The relation of water surplus and water deficit constitutes of the index of humidity. The potential evapotranspiration is worked out through indirect methods given by Thornthwaite (1946, 1947 and 1948) Thornthwaite and Mather (1955) Penman (1956) Van Bavel (1956) Ojo (1969) and Hargreaves (1977). They have developed formulae for estimation of potential evapotranspiration in India. The water balance methodology given by Thornthwaite and Mather (1955) has been used widely by late Prof.V.P.Subrahmanym. He was a Pioneer worker in the field of water balance studies and has published a monograph in 1982 on application of water balance techniques in India. Subrahmanyam (1956, 1957, 1959, 1963, 1967, 1982 and 1983) has carried out studies in application of water balance studies for the index of continentality, relation to distribution of natural vegetation continentality trends over India, hydro climatology and water balance of Chandra Palem basin.

A National Symposium on water balance and National Development is organized by late Prof.V.P.Subrahmanym on 19th, 20th, 21st December 1983 in the Department of Meteorology and Oceanography, Andhra University Vishaka Patnam. The symposium covered various of aspects of water balance in application of agriculture, hydrology, hydro climatology of river basin and

Land use in any region is the complex diversified and dynamic concept. It is a functional concept. Land uses are distributed in interactive mixers, that all some times mutually comparable and some times mutually complicating. According to Vink (1975) the concept of the land use is considered as a relatively stable subject, related mainly to the use to which the land in a certain region at a certain a time is put. It’s use is the result of a continuous field of tension created between available resources and human needs. Sauer (1919) defined land use as the land used to which the entire surface is put. Stamp (1952) stated that the land has a whole must be so used and satisfy as many as possible of the needs and legitimate desire of the people. Vanjetti (1970) has described land utilization is concerned with the type of use which man carries out over a certain area at a certain a time. Reddy and Ramanaiah (1990) have described that the form and function of the land use is a human enterprise, while the development of landscape is the continuous afford of man for his needs and is a combination of climatic, vegetative and soil conditions. The need for land use studies is much more important especially in areas where the kind and degree of land use form the main sources of the regional economy. Anderson (1971) has stated that land use data are needed in the analysis of environmental process and problems that must be understood is living standard and are to be improved to
the maintained current levels. According Sinha (1971) land use planning should not be considered as the rational use land put to cultivation and bringing more land under the plough. It should also included conservation of land from erosion, development of nutrition through multiple cropping systems, improving the fertility of land, application of modern technology and lastly prevention over exploitation of land. A study of arable land is an essential for the rational and optimum utilization of land resources of the region.

According to Simons (1978) the maps of land use became recognized as an essential tool of regional planning development. Jasbir Singh (1974) stated that the standard definitions of the land use types are essential pre-requisites for improving the reliability and comparability from year to year and place to place. At present there is no standard land use classification system in India. Gautham and Narayanan (1982) have developed land use classification scheme based on remote sensing techniques. These techniques being used affectively to survey the land resources and map them meaningfully.


Irrigation is defined as the artificial application of water to plants. It is a farming practice designed to supplement the water in areas of excess potential evapotranspiration where evaporation and there is deficit rainfall in a region. Irrigation plays an important role in the development of agriculture. According to Ahmad (1971) irrigation can do more support for farming activity and can lead to a successful agriculture. Haries (1972) stated that irrigation facilities bring innovative results in agriculture. Most of the green revolution areas have succeeded in high agriculture production because of high irrigation intensity areas. Swaminathan (1978), Das Gupta (1980) stated that the bulk increase in food production in future will come from expansion of irrigated areas. Harning (1971) stressed the significance of effective irrigation and water management in agriculture. He added that irrigation has been mainly considered as means to bridge for droughts or to water deserts. The land irrigation
acts has a catalytic agent for adaptation of modern agriculture technology.

Cropping pattern represents the spatial crop sequence in a given area at a particular point of a time. It presents the relative proportion of area under different crops at given point of a time. According to Ramanaiah 1984 cropping pattern may be defined as the spatial and hierarchical arrangement and association of different crops at a point of time in a particular area unit. The concept of cropping pattern has been a complex and dynamic phenomena. Cropping pattern of the region is a reflection of interplay of the diversified, physical, socio economic, technical and organizational factors. A cropping pattern of a given area at particular of a time is the most effective use of land. However, it not static and it changes with progress in technology and socio economic condition.

The committee constituted by Govt. of India in 1960 determined the cropping pattern according to relative acreage of various crops in an area. The Agriculture Committee divided the whole country in 103 cropping zones. According to them cropping pattern means cropping scheme and cropping intensity best suited for the land. A symposium of cropping pattern in India was sponsored by Indian Council of Agriculture Research (ICAR) in 1968.

In this symposium the committee has suggested various agro climatic and soil regions for irrigated and un-irrigated conditions. In each of the agro-climatic and soil zone the suitable crops have to be identified and the cropping scheme has to be developed. The National Commission on Agriculture has evaluated a suitable
cropping pattern based on the rainfall region and identified 160 rainfall patterns on all India basis. The agro-climatic and soil zones of India for kharif and rabi seasons are prepared. Based on the proceeding of the symposium on cropping pattern in India the Agriculture committee has recommended for multiple cropping, plantations, intercropping, intensive cropping of food crops and cultivation of fruits and crops in sandy soils. It has also recommended various research programmes related to cropping pattern, management of water resources and agro climatic zones.


Raman and Srinivasmurthy (1971) have divided the year into four periods on the basis of the values of actual evapotranspiration and potential evapotranspiration. According to them when \( AE = PE \) then the humid climate prevails, when \( AE \geq 1/2 \) of the potential evapotranspiration then the wet climate exists, when \( AE \geq 1/4^{th} \) of the potential evapotranspiration then the moderately
dry climate prevails and when $AE \geq \frac{1}{8}$ of the potential evapotranspiration then the dry climate exists.

Subrahmaniam and Umadevi (1983) have studied the water availability days and calendar and crop management in Orissa state.

The thesis is divided into nine chapters. The first chapter consists of introduction, study area, objectives, and methodology and review literature. The second chapter speaks about distribution of rainfall, rainfall intensity, rainfall variability, rainfall ratio monthly, seasonal, annual basis of the Rayalaseema region. The third chapter describes the monthly, seasonal and annual distribution of water balance elements of the Rayalaseema region. In the fourth chapter water availability days, water availability calendar are described. The fifth chapter deals with concentration of land use and land use efficiency of the Rayalaseema region at mandal level. The sixth chapter an attempt is made to describe various sources of irrigation, concentration, intensity, and efficiency at mandal level of the Rayalaseema region. The seventh chapter tells about the distribution of crops, intensity of cropping pattern, crop diversification, and crop combination at mandal level of the Rayalaseema region. In the eighth chapter the relation between the water balance elements, land use efficiency intensity of irrigation and crop diversification are described. Based on water availability days and calendar the crop suitability map of the Rayalaseema region is prepared. Lastly in the ninth chapter the summary and conclusions are presented.