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6. Chemical, Physical and Water Resources Management of The Geographical Locations Over

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Abstract:

The modern economy is the resources based economy, and the development of a country or a region is based on the resources and especially on the natural resources. Retrival of the resources through scientific technology developments is main way to acquisition of the resources like water, air, heat, natural vegetation soil, Animals, metal, fossils etc. Depends on the resources availability, the resources were classified in to physical resources, forest, Agricultural, and Animal and fisheries resources. There are many parameters will be controls the enhancement and reduction of the each resources. Geographically the visakhapatnam district located beside the coast of Bay of Bengal and one of the north eastern coastal districts of Andhra Pradesh State and it lies between 17°15' and 18°32' Northern latitudes and 81°54 ' and 83°30' Eastern longitudes, The total geographical area of the district is about 11, 34, 282 hectares. The physical resources mainly controlled by the climate, soil and water. Physical resources will play major role in development in human life span and growth. Comprehension about the identification of physical resources and their management for future should be main concern in this paper. This study will be useful to sustainable development of resources in the district.

Keywords:

Resources, Visakhapatnam, Andhra Pradesh, Physical, Animal, forest.

6.1 Introduction:

The modern economy is a resource-based economy and the development of a country or a region is based on Natural resources. Nature has given us abundant resources in the form of

water, air, heat, natural vegetation, soil, wild animals, metals, fossil fuels, etc. Man by his technical skill and knowledge is using all these resources in some way or the other right from the dawn of civilization. In the process of utilization of resources man often misuses its availability, thus affecting the natural ecosystem. In the context of present day shortage of available resources, a scientific inventory of these valuable natural resources and proper way of their utilization assume considerable importance. Responsible management of natural resources is essential to achieve sustainable development and livelihoods for present and future generations. Resource refers to the positive interaction between man and nature. Man improves his knowledge and develops new resources to meet his increasing demands. More recently the concept of natural resources has been broadened to include the total natural environment, that is, the entire surface layer of the Earth; because all parts of the Earth's surface are production of necessities and amenities that people demand. Thus from this point of view all living and non-living elements of the Atmosphere, the Oceans, and Earth too have valuable resources. All these resources are to be utilized scientifically and managed with care to provide necessities and comforts to the present and future generations.

The planet Earth holds a finite stock of resources and should vary through time and across space. **Zimmerman (Peach and Constantin** (1972) states: 'the word "resource" does not a substance, but a function that a thing or a substance may perform, or to an operation or 'as dynamic as civilization itself.' Each major human civilization was sustained by a particular set of resources and technologies for their exploitation **(Simmons 1996).** The archaeological record talks of the Stone Age, the Bronze Age and the Iron Age. In reference to the Industrial Revolution of the nineteenth century**, Simmons (1996**) states that: 'industrialization based on fossil fuel energy represents a turning point in the history of human-nature relations.' the twentieth century will be seen as the era of oil and gas. Natural resources are living and non-living components of nature which are being used by humans for meeting their requirements.

The natural resources are obtained only from Earth, what we called Earth resources. Natural resources may be classified in to (I) Biotic and Abiotic, (II) Exhaustible and Inexhaustible, (III) Potential and Developed Resources, (IV) Energy, Mineral and Agricultural Resources. Biotic resources nothing living and renewable resources which include Forests and their products, agricultural crops, animal fodder, and fishes Abiotic resources consist of non-living things and mostly non-renewable. Minerals and fossil fuels, Minerals are a biotic resources. These resources are exhausted by use while their rate of formation is exceedingly slow. Once these minerals, petrolium are taken out the

We cannot be replaced what we called Exhaustible. Resources which can be renewed by reproduction or by physical, mechanical, or chemical processes are known as inexhaustible resources like solar energy, water and human beings are examples of inexhaustible resources. The power that could be generated if all the water power resources in the country are used is known as its potential resources and hydroelectricity generated is known as a developed resource. The potential resources when they are developed by man. Human effort transforms the environment to satisfy the needs of man. The resources used as power to run various machines are known as energy resources. Electricity is becoming more important in the world's economy. Nuclear energy obtained from uranium and thorium is a modern source of energy.

A. Recent Trends in Resources Development:

Man interacts with the elements of nature and thus transforms the natural endowments for his benefit. As wants and knowledge expand with time, man involves himself more and more in creating newer and superior resources. He has also invented machines which were, perhaps, rather simple in the beginning, and mass production of goods within a very short time. Almost every member of a modern society is getting the benefit of such resources.

B. Resource Management:

The conservation of natural resources is a concept that deals with the rational use of resources. This is not only necessary to assure long-term resource use but also to protect the ecosystem. Now days, every country is very particular regarding its natural resources and tries to genuinely adopt conservation policies. Resource conservation is the scheduling of resources use so as to provide the greatest yield for the greatest number over the longest time period (**Haggett, 1972**). **John F. Kennedy**, in a special message to the Congress in 1962, interpreted conservation as "the wise use of our natural environment, the prevention of waste and despoilment while preserving, improving and renewing the quality and usefulness of all our resources". Conservation of resources is essential for the survival of man. Conservation of resources has economic, aesthetic and scientific value for mankind.

C. Sustainable Development:

The question of sustainable development has emerged due to overexploitation of resources and due to mismanagement of technology. The aspects which require monitoring of sustainability include climatic change, biodiversity, disposal of hazardous and toxic wastes, disposal of pollution generating industries and food and ecological security.

Swaminathan (1991) has identified nine principles for desired success in promoting ecologically-sound agriculture. They are (i) land, (ii) water, (iii) energy, (iv) nutrient supply, (v) genetic diversity, (vi) pest management, (vii) post-harvest system, (viii) systems approach, and (ix) location-specific research and development. With his technological and scientific skills, man has made rapid developments in agriculture, irrigation, mining, industries, transportation, forestry, land management and other areas. Unfortunately, in doing so, there has been much disruption of the functioning of natural environment. Now, people have begum to realize the side effects of the developmental activities and have started their efforts in minimizing these effects by adopting methods and technology for issues associated with development.

Sustainable development is the need of the present time not only for the survival of mankind but also for its future protection. On the technical level. Visakhapatnam district comprises of rich forests and more than 40 percent of the total geographical area is under forests. But in the recent years there is decline in the extent of forest cover and also degradation in the floral species due to anthropogenic activities. Agriculture is another important resource of the district and it is the main occupation of the people. Visakhapatnam is known for marine fisheries and large quantities of fish are being exported to foreign countries. Visakhapatnam is fast growing industrial city and experiences rapid urbanization. Except city region, the

rest of the 90 percent of study area is economically backward. Now, the government of India is trying hard to evolve a workable and acceptable strategy for developing the backward areas and allocating more funds for rural development programmes. For that, problems of each region should be studied to identify the areas of need and to make sound recommendations and land use including its landforms, climate, soils, forests, animals and agriculture. Hence, an attempt is made to assess resource base of the study area and possibilities of multiple uses of available resources for the development of the study region.

Many disciplines such as Environmental, Biological, Bio-geographical and Earth sciences have focused on the distribution pattern of natural resources and their conservation. Krishna Murthy (1980), discussed about the types of forests, forest products, relationship between forests, ecology and environment. **Pushpa Kumar (1982**) has analyzed wild life sanctuaries in Andhra Pradesh. **Natarajan (1982**) studied the resources and development of inland fisheries of Eastern Ghats. Some of the studies dealt with resources conservation and environmental management, which include **Saxena (2007), Singh (2009), Dikshit (1991), and Sharma (1995).** Prithwish Kumar Roy (2000) has analyzed the concept of resources and resource distribution both in India and the world. **Bahuguna (1986)** and **venkata Reddy (1988)** analyzed the degradation of forest areas and also assessed the impact of deforestation on environment and ecosystem. **Sadhu singh (1980) Agarwala (1990) Sen Sarma (1993)** and **Singh and Sikka** (1994) discussed about forest development and forest farming for improvement of forest resources in the country. Basil Hans has suggested a holistic approach in resource management for sustainable development. **Ramakrishnan (2003)** examines various possibilities of the studies analyzed the economic activities like development of forest based industries, employment generation, production of forest produces and possibilities for recreation development in forest areas. Deforestation and environmental degradation was discussed in detail by **Savindra Singh (2004) Madhava Rao. Hermon (2003)** has analyzed biological resources of India. Saxena (2007) has discussed about conservation of resources and sustainable development. Intensification of resource use and diversification of occupation pose serious challenges to balance economic for sustainable management of natural resources. International organizations like IGBP (International Geosphere & Biosphere Programme) have emphasized on resource management and sustainable development.

6.2 Data and Methodology:

Visakhapatnam district is one of the north eastern coastal districts of Andhra Pradesh State and it lies between 17°15' and 18°32' Northern latitudes and 81°54 ' and 83°30' Eastern longitudes (Figure 1.1). It is bounded on the north partly by Orissa State and partly by Vizianagaram district, on the south by East Godavari district, on the West by Koraput district of Orissa and on the east by Bay of Bengal. The total geographical area of the district is about 11, 34,282 hectares and the total population of the district is about 38, 32,336 as per 2001 census. Administratively the district is divided into 3 Revenue divisions and 42 mandals including the urban and rural mandals of Visakhapatnam**.**

The study is primarily based on secondary data sources published by the time series data pertaining to natural resources, land utilization, area and production of principal crops, livestock and fisheries were obtained from the **Directorate of Economics** and Statistics.

Climatic data have been collected from the records of **India Meteorological Department**, Pune and also rain gauge stations located in the study region. The information about the distribution of forests, soils, crop yields, coffee plantation, sericulture and ground water potential in the study area have been collected from the **Departments such as Forest Department**, **Ground water Department, Coffee Board, Departments of Sericulture** and **Revenue Department** and **Planning and Statistics** department. Data pertaining to various aspects of resources have been collected from the records of **District Administration office,** and **Mandal offices**. The commonly used parameter for these studies is the coefficient of variability of rainfall given by the expression.

$$\text{Coefficient of precipitation Variability} = \frac{\text{Standard deviation}}{\text{Mean rainfall}} \times 100$$

These coefficients have been computed for all rain gauge stations in the study area and the rainfall variability Secondary data have been collected from **ground water department**, Visakhapatnam and water quality has been assessed. Based on this information, analysis of data was carried out and results are presented. The main aim of the study is o assess the resource potential of the study area particularly biotic resources. To analyze the general land use pattern of the study area. To study the physical resources including climate, soils and water resources. To find out ways to raise the existing resources to suggest measures for conservation and potential use of the available resources for sustainable development. In the present study, an attempt has been made to analyze climatic elements, rainfall and temperature and their seasonal distributions. A rainy day is defined by the **Indian meteorological department** as a period of 24 hours during which a total rainfall equal to or more than 2.5 mm is received.

6.3 Results and Discussion:

A. Climate:

Climate is an active factor in the physical environment of all living things and human welfare range associated with climate change. Changing climate affects the frequency and intensity of weather events like floods, droughts, cyclones, heat waves and other disasters and in turn results in property damage, crop failures, famine or deaths. Therefore, climate plays a significant role in day to day life of man and economic activities of the people.

The study of precipitation distribution over the district is based on rainfall data collected from local rain gauge station shown in (Figure 1.2). The average annual rainfall in the district is 1082 mm and it increases from the coastal region towards the west and northwestern parts of the district which are hilly. The district gets rain both during the south-west monsoon and retreating monsoon seasons. The rainfall during the south-west monsoon months (June to September) amounts to 58 percent of annual rainfall and that during the post monsoon months of October and November amounts to 28 percent of the annual normal. September and October are the rainiest months each of which accounts for about 19 percent of annual rainfall. Significant rain of about 10 percent also occurs during the pre monsoon months of April and May. The mean annual rainfall distribution over the district

is shown in (Figure 1.3). The coastal plain receives rainfall between 950 mm and 1000 mm whereas the hilly region in the north and the west receives higher amounts of rainfall varying from 1150 mm to 1250 mm. The hill station, Araku gets the highest amount of 1265 mm of rainfall. The other high land stations, Dumbriguda receives 1224 mm of annual rainfall followed by Hukumpeta with 1200 mm of rainfall (Table 2.1). The isohyets run parallel to the coast in the plains towards interior and rainfall increases from the coast (950 mm) towards north (1250 mm). The rainfall distribution over the district during the four conventional seasons is shown in (Figure 1.4). The district receives the major portion of its rainfall from the south-west monsoon and higher amount of precipitation was recorded over entire region during south-west monsoon, compared to other seasons. Mean seasonal rainfall during the south-west monsoon varies from 550 mm along the coastal belt and 800 mm in the north due to orographic effect. The pattern of distribution of rainfall during this season is almost similar to annual pattern of rainfall. During the retreating monsoon season, the district exhibits different type of trends in distribution of rainfall. Coastal region receives higher amount of rainfall due to cyclonic activity. The rainfall decreases from 325 mm along the coast and 200 mm towards interior region. The two seasons seem to act in a complementary manner to each other in their spatial behavior, while the coastal stations receive less rainfall and hill stations receives higher rainfall in the south-west monsoon season; the former receives higher rainfall and less rainfall during the retreating monsoon. The rainfall maintained gradient towards the coast in the monsoon period and is towards interior during the retreating monsoon period. The district receives very meager amount of rainfall during winter and is the dry season. The rainfall varies from 25 mm in the east to 10 mm towards west. During the summer season, the region receives rainfall on account of convective activity. The rainfall pattern during this season resembles that of the south-west monsoon with lower rainfall amount i.e., 100 mm along the coast and increases towards interior and hilly regions where it varies between 150 mm and 200 mm.

B. Variability of Rainfall:

An important aspect of rainfall that determines its agriculture usefulness in any region is its variability which is a measure of its dependability or consistency. While preparing plans for agricultural development, this crucial aspect may be given special attention. is shown in (Figure 1.5). It is evident from the figure that the coastal areas have lower variability of 25% whereas interior areas have higher degree of variability of 30%. The highest coefficient of 35 is recorded in the north-west, hilly region of the district. It is a common observation that areas of high rainfall amounts have low rainfall variability and low rainfall areas have high variability. In the present study, however, it is interesting to observe that the highland stations which register high amounts of rainfall have higher variability compared to the coastal stations which receive lower rainfall. The lower coefficients of variability and greater rainfall dependability were observed in the coastal areas and higher coefficients and less rainfall stability in the interior areas.

C. Number of Rainy Days:

On comparing the average number of rainy days per year in the district, coastal stations are found to experience less number of rainy days with 50 to 60 days per year where as hill stations have 70 to 80 rainy days (Figure 1.6). The trend resembles the yearly rainfall

distribution pattern which shows an increase from the coastal stations to the interior hilly stations. In order words, on an average, one day for every 7 days in the coastal zone and one day for every 5 days in the hilly zone may be expected to receive significant rainfall. This rainfall interpretation should useful to the Development of physical resources as soil.

D. Temperature:

The Visakhapatnam district has various topographic diversities and long coastline determine the distribution with highest peak in May, which is the hottest month and the second peak in the month of September or October after the withdrawal of the monsoon. The temperature varies from place to place in the district during different seasons. In interior plains the temperature in summer are about 2°c to 3°c higher than in the coastal plains. But in the monsoon season this variation in temperature does not appear to be significant on account of the higher percentage of atmospheric humidity all over the district.

Similarly in winter the minimum temperature in the interior plains are lower than those on the coast by about two degrees which is due to the general dryness of the air in the interior and another reason is water body takes long time to cool down compared to land surface and hence higher winter temperature along cost. During May and the early part of June before the onset of the monsoon, the day temperature may occasionally exceed 43°c. There were cases when maximum temperature exceeds 45°c and people were subjected to discomfort due to heat wave conditions.

The average annual temperature is mapped and presented in Figure 1.7 It can be observed that the temperature decreases from 26°c along the coast to 24°c in the interior plains. The elevated regions in the north-west exhibit temperatures of less than 24°c and Araku valley in the north shows 22°c only. In the hilly tracts the temperature in general may be lower than in the coastal region by about a couple of degrees or so, depending on elevation. Figure 1.8 represents the temperature distribution during winter season.

The isotherms of the mean minimum temperature of the coldest month (December) show that the temperature decreases from 18° c along the coast to 10°c in the hilly region. Araku valley in the north records the lowest minimum temperature of 8°c in entire district. Mean maximum temperature of the hottest month Figure 1.9 shows that the highest temperature, 36°c prevails along the coast and it decreases slowly towards interior, foot hill zone and further low maximum temperature of 32°c in the hilly tracts in the north and north-west of the district. The general rule in the distribution of temperature i.e., temperature decreases with increasing distance from the sea coast is clearly exhibited.

E. Humidity:

In study area the humidity decreases from the coast towards interior. The coastal stations like Visakhapatnam, Bhemunipatnam and Konada show higher percentages of relative humidity which vary from 75 percent to 85 percent whereas interior stations like Anakapalli and Chodavaram exhibit lower percentage of humidity varying from 55 percent to 75 percent. All the stations show high percentage of humidity during monsoon season.

F. Wind:

Winds are generally light to moderate in speed with some strengthening during the summer and early south-west monsoon seasons. Wind direction and wind speed during different seasons at Visakhapatnam is shown by wind roses (Figure 1.10). The two main wind directions at Visakhapatnam are south-westerly during the south-west monsoon (summer) and easterly during the north-east monsoon (winter). The gales will occur during the cyclone season and wind speed varying from 20 to 60kms per hour (khr). The maximum percentage of calm condition occurs during winter period. Storms and depressions originating in the Bay of Bengal during the post monsoon season due to high temperature (>26°c) and strong winds during pre-monsoon season and heavy rains across the coastal zone of the district.

G. Bio-Climatic Classification:

The climatic data, monthly and annual rainfall and temperature have been analyzed as per the criteria laid down by **Koppen**. As the region is small and hardly exhibit climatic variation, the entire Visakhapatnam district may be broadly classified as Tropical Savannah (AW) climate. The general characteristics of this climatic type are the mean temperature of the coldest month is above 18°c and the rainfall in the driest month is less than 10-r/25 and the climate is hot and seasonally dry.

Thornthwaite scheme was also applied to identify bioclimatic types. The potential evapotranspiration is main parameter to understand the direct relation to growth and development of vegetation. Based on the computations from the water surplus, water deficiency, actual evapotranspiration from potential evapotranspiration, precipitation of any given station, the index of humidity and an index of aridity can be computed., moisture index can be derived. Using this water balance concept of Thornthwaite, moisture indices have been computed for all the stations under study to identify the climatic types of the Visakhapatnam district. As per the climatic classification of Thornthwaite under moisture regime, the district can be delineated into three climatic types, (Figure 1.11) moist sub humid (C_2) along the hilly region, dry subhumid (C_1) along the foot hill zone or interior plains and semiarid type of climate (D) along the coastal plains.

6.4 Soil Resources:

A. Distribution of Soils in the Study Area:

Three types of soils can be distinguished in this district depending upon the parent rock formation. The main types of soils in Visakhapatnam district include red soils, alluvial soils and coastal sands. Black cotton soils are only at two places in negligible percentage **(Table 1.3 A).** They are brick red in clolour, coarse textured and of shallow depths less than one meter. These soils are acidic with pH ranging from 6.0 to 6.5. They are poor in humus, nitrogen and phosphate contents. Concretionary aggregates of both calcareous and ferruginous composition are commonly seen. These soils are generally found in and around Visakhapatnam, Chodavaram and Ananthagiri regions.

The soils are grayish black to olive brown in colour. Usually these soils are of transformed nature, have uniform texture, high to medium plasticity and low to medium permeability. The pH is 7.0 to 8.0 and soil depth is over one meter, well supplied with plant nutrients, and rich humus. In the interior plains and foot hill zone the soils are red ferruginous loams and sandy loams in the hills and valleys, which support luxuriant growth especially of teak and its associates. At elevations above 1,000 meters the soils are bauxite ferrous, laterites supporting only grasses. Sandy soils of khondalites and quartzites which are brick red in colour and coarse textured. The third types of soils are coastal sand dunes of quartzites and these are highly permeable and porous with low organic nutrients.

In the hilly regions, red loamy soils are under a warm humid climate and weathering of parent rocks to brown to reddish, sandy to loamy type with frequent laterite rapping. The soils are medium to fine grained and essentially non-clay and hence susceptible to erosion particularly because of the undulating nature of the ground. The soils are deficient in lime, nitrogen and phosphoric acid and tend to be acidic. The soils in the broad valley are deep and the fertility status is moderately good when compared to the soils on the hill slopes. The lateritic soils though poor in fertility status respond readily to manuring and good cultivation. The fertility index or nutritional index is considered for determining the fertility of soils. The major indicators to determine the soil fertility is Organic Carbon (OC), phosphorous (P_20_5), and potassium (K_20). The concentration of organic carbon is low in the entire study area during 2009. **(**Table 1.3 B**)** Phosphorous concentration is low in the hilly region and it varies between medium and high ranges in the interior and coastal plains. Potassium concentration is high in hilly region and varies and also along the interior and coastal plains. When compared the fertility indices of soils of 2009 period with the values of 1998, the soils of study area have been loosing their nutrient values due to soil erosion. (Table 1.3 B) as the indices values are very low 2009.

B. Soil Degradation in Study Area:

There are number of physical and cultural factors responsible for the depletion and erosion of soils, such as slopes, rainfall, temperature, wind, snowfall, and man's actions like deforestation, overgrazing and unscientific cultivation etc. Shifting cultivation is one of the environmental problems in the study area which is responsible for soil erosion in the forest areas of the district. Soil erosion due to run-off water is the main problem owing to the high intensities of rainfall and due to the vast elevation differences ranging upto 5,500 ft. from the sea level, the sea coast is also subjected to erosion due to sea waves. The erosion losses are much more in steep slopes which are generally situated in agency area and are aggravated where 'Podu' cultivation is in vogue which is the general practice in agency area. Because of the peculiar topography all types of soil erosion, viz., (i) Sheet erosion, (ii) Rill erosion, (iii) gully erosion, (iv) wind erosion and (v) wave erosion are noticed in this district. Run-off and internal drainage is excessive on the northern portion of the district and impeded of restricted in the middle and adjoining areas of Bay of Bengal. As regards soil conservation measures to be taken up in this district, it is necessary to take up graded bunding in about 4.20 lakh acres (areas with 1 to 10 percent slope), bench terracing in 0.24 lakh acres, gully control works in about 0.28 lakh acres and stone terracing in 0.25 lakh acres (area with 10 to 20 percent slope and where stones are available in plenty). Afforestation is to be done in 0.50 lakh acres and pasture development is about 0.14 lakh acres.

C. Soil Conservation:

Under soil conservation programme in the study area, the district it is divided into six major catchments viz., (i) Champavathi, (ii) Gosthani, (iii) Narvagadda, (iv) Sarada, (v) Varaha and (vi) Thandava. These catchments can further be divided into sub-catchments to facilitate tackling the areas easily and effectively. Among these, the priority catchments are Thandava and Gosthani as there are already existing projects on these rivers.

6.5 Water Resources:

Most part of the study area is drained by Varaha and the rest by Tandava Rivers which are non-perennial. Much of the water is being wasted and flows down to the Bay of Bengal since there are very few projects of artificial drainage to tap this resource for use in dry periods. The normal annual rainfall in this area is 1202 mm. of this, during southwest monsoon (June to September) about 713 mm, northeast monsoon (October to December) about 295 mm, and during winter and summer periods (January to May) about 194 mm of rainfall are received. There are no major irrigation projects in the study area. The medium irrigation projects include Thandava, Konam, Raiwada, Kalyanapulova and Padderu reservoirs and the total net area being irrigated under these schemes accounts for 36,833 hectares (Table 1.4). The minor irrigation schemes include Ravanapalli, Ghamburamgedda, Seshugedda, Rangabolugedda and NTR reservoirs which include 2,211 hectares of irrigated area. Other sources of minor irrigation include dug wells, shallow tube wells and deep tube wells. The total area irrigated under principal crops is 183,192 hectares during 2007-2008. There are many minor irrigation tanks which are not able to irrigate the entire registered ayacut areas because of heavy rate of siltation. The existing Machkund and Jalaput reservoirs also are getting silted up though at a reduced rate because of certain important soil conservation works executed in the watersheds. In order to protect these reservoirs and minor irrigation tanks soil conservation measures are to be taken up urgently.

In this district medium sized rivers and hill streams flow and hence perennial sources of irrigation are lacking. The major irrigation sources in this district are the rivers flowing in the district, the hill streams and irrigation tanks. The chief rivers in the district are Sarada, Varaha, Thandava, Gosthani, Champavati, and Meghadrigedda. River machkund also known as ‘paleru’ and ‘sileru’ flows on the northern border of paderu and chintapalle taluks and does not afford irrigation facilities. Amongst the rivers that flow, Sarada, Thandava and Varaha rivers provide maximum irrigation facilities in this district. There are two fresh water lakes viz., Komaravolu Ava and Kondakarla Ava which are although of not great depth have not dried up and proved themselves to be very useful for irrigation purposes.

The tapping of underground water through wells and tube wells is also very important. The use of underground water however lowers the water level in wells. Therefore the use of underground water has to be judicious and coordinated with the water supply available from other sources. The water table fluctuates on an average 3 meters between rain season and summer season. By and large shallow wells are common in Kondalites (5 m deep), moderate (5 m-8 m) in Charnockites, and deep (8m-15 m) in Quartzites. The supply of water in the hills is plentiful, moderate in the plains and poor along the narrow coastal belt. The pH of water turns more alkaline as one proceeds away from the hills.

A. Water Resources in Hills and Foot Hill Zones:

There are many perennial streams in the hills and also in the plains. Due to high rain fall in Eastern Ghats the water supply is satisfactory in these areas and there is no scarcity for drinking water. The important perennial rivers are Sileru, Varaha, Thandva. In the Sileru Catchment area there is hydroelectric project at Machkund. For this project, reservoir is constructed at Jalaput which comes under Pedabayulu region. The flow of drainage is from north-west to south-east in accordance with the general slope of the land. Many of the hill streams in Chinthapalli drain into Sileru River, which in turn joins Sabari, a tributary to river Godavari. The Varaha River drains the areas of Chinthapalli, Narsipatnam and joins the sea at Revu-Polavaram. The Thandava River drains the Gudem agency, Chinthapalli and Golugonda plains and joins the sea at Pentakota. The catchment areas for most of the rivers are the groups of hills. There are few major tanks and many minor irrigation tanks in the area. Depth of water table varies considerably and leaves no relation to the proximity of sea or a perennial water source.

There is good number of small tanks in the forests. They retain water for some part of the year and dry up mostly in summer. Bore wells are laid in villages. These cater to the water needs of the villages. Undulating character of the terrain of this district lends itself favourable to irrigation from tanks and wells. A number of tanks and reservoirs are the sources of irrigation in the district. In the last 15 years, 3 medium irrigation projects have been constructed viz. Raiwada, Konam and Kalyanalova. Consequently, ground water table has increased in the command area of these reservoirs.

B. Ground Water Quality:

An attempt has been made to analyze the ground water quality in the study area. Table 1.5(B) shows, the physico-chemical characteristics of ground water samples which were obtained during summer season of 2009. All the chemical constituents are expressed in mg/L (milligrams/liter) except pH. The pH of ground water in this study area is varying between 8.1 and 8.6 and they are within desirable limits. TDS values are varying from 133 mg/L in hilly area to 413 mg/L in the coastal plains. Rambabu and somasekhar Rao, 1996 have expressed that the dissolution of soil particles containing minerals under slightly alkaline conditions favors in increasing the TDS concentration in ground water. TDS value above 1500 mg/L cause gastrointestinal irritation according to Bhavani Sankar and Muthu Krishna, 1994. In the present study TDS values were within permissible limits. Hardness is an important criterion for determining the usability of water for domestic, drinking and industrial purposes. Total hardness of ground water in the study area varies from 153 mg/L in hilly areas to 413 mg/L in coastal plain areas. The acceptable limit of total hardness for drinking water is specified as 300 mg/L. The hardness of the water is due to the presence of calcium and magnesium. However, iron, strontium, barium, manganese and aluminum also contribute to hardness (Saritha et.al, 2009). It was observed that the water samples from interior plains and coastal plains exceeded desirable limits (Table 1.5 (A). Chloride concentrations are varying from 14 mg/L in hilly region to 140 mg/L in interior plains. The limit of chloride concentration for drinking water is 250 mg/L. Chloride concentration of the ground water is within the permissible limits in the study area. Fluoride concentrations vary from 0.1 to 0.3 mg/L and they are within permissible limit of 1.0 mg/L and ground water is free from fluoride pollution. Calcium concentrations of the ground water ranged

between 5 mg/L in hilly region and 74 mg/L in coastal plains. The limit of calcium for drinking water is specified as 75 mg/L (Table 1.5(A). It was observed that the calcium concentrations are within permissible limits in all the regions of the district. Magnesium concentrations are varying from 16 mg/L in hilly region to 70 mg/L in interior plains and upland regions. The limit of mg concentration for drinking water is specified as 30 mg/L. Magnesium content in the water does not have any health hazard. But it contributes to hardness in water. It was observed that mg concentration crossed the permissible limits both in interior plains and coastal plains.

C. Changes in the Levels of Ground Water:

Data with regarded to ground water levels in the study area and changes over a time period of 20 years are presented in (Table 1.5). The average depth of water levels from the ground level has been relatively higher in the hilly region when compared to other regions of the district both in pre-monsoon and post-monsoon seasons. It is also observed that the depths of water levels are showing an increase between 1989 and 2009. In hilly region the depth of ground water level increased from 10.85 m to 11.13 m in pre-monsoon season and the same trend is observed in post-monsoon season with an increase from 6.69 m to 9.32 m. between 1989 and 2009. Same trend was observed both in interior plains and coastal plains. The average depth of wells is increased from 5.37 m to 5.6 m in pre-monsoon season and from 2.87 m to 3.67 m in post-monsoon season in interior plains whereas the increase is from 4.6 m to 5.7 m in pre-monsoon and from 2.7 m to 3.8 m in coastal plains during 1989 -2009. It can be observed that in respect of post-monsoon season all the regions show a steady increase in the depth of water levels over a period of 20 years. There is an increase in depth of water levels during pre-monsoon season also but significant increase is observed during post-monsoon season between 1989 and 2009. This may be due to poor recharge of ground water which may be attributed as rapid changes in vegetation cover.

D. Management of Water Resources:

The water distribution system should be such that loss of water should be minimum and it should remain free from pollution. A few general steps for distribution of water are: As far as possible water distribution be done through pipes so that loss will be minimum and water will remain free from pollutants. The channels and distributors of canals should be cemented, and in fields also either pipes be used or cemented channels be constructed. For irrigation, sprinkle and drip system be used. If possible, water tanks should be covered to avoid evaporation and also for cleanliness.

The overexploitation of underground water often results in the lowering of water table, intrusion of saline water, subsidence of land, etc. the prime need is the proper and limited use of water and also geological and hydrological survey of the region for assessment of water availability. The system of the recycling of water is used so that waste water can be used for irrigation purposes. The loss of vegetation is also a cause of drought and reduction of rainfall and indirectly a cause of lowering of the water table. In order to maintain humidity in the atmosphere which helps in rainfall and to minimize evaporation rate forest cover should be maintained.

E. Protection of Water from Pollution:

Apart from availability of water, quality of water is also important, in other words water should be free from pollution. The nature and types of water pollution and its effects have been discussed. Nowadays, several techniques such as Physico-Chemical purification methods, hydrolysis, electrolysis, ion-exchange, absorption, chlorination, ozonisation, etc., are in use. Similarly, biological purification method is also in use. The conservation of water can be done only through proper water management system. Apart from above mentioned measures though expensive, water can be obtained from desalination of sea water and even by artificial rainmaking. Apart from conservation of water, mutual cooperation in use of water resources is necessary.

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Table 1.1: Temporal variation of Land utilization in Visakhapatnam district

Sr. No	Land use categories	Visakhapatnam (% to total geog. area)		
		1987-1988	2007-2008	change in percentage
1	Forest	41.8	39.53	-2.27
2	Barren and uncultivable land	16.9	11.68	-5.22
3	Land put non agriculture uses	7.0	9.22	+2.22
4	Cultivable waste land	1.2	1.0	-0.2
5	Permanent pastures & Grazing land	0.4	0.29	-0.11
6	Tree crops	1.8	3.05	+1.25
7	Other fallow land	1.3	2.8	+1.5
8	Current fallow land	7.8	4.39	-3.59
9	Net sown area	21.8	27.96	+6.16

Table 1.2: Visakhapatnam District - Seasonal and Annual Rainfall (Mm)

Sr. No	Mean Seasonal Rainfall					
	Station	Southwest monsoon (A)	Retreating monsoon (B)	Winter season (C)	Summer season (D)	Mean annual rainfall
1	Chinthapalli	783.2	200.9	16.0	182.8	1,182.9
2	G.K. Veedhi	818.0	195.0	12.0	163.0	1,188.0
3	Paderu	762.0	219.0	13.0	185.0	1,1993
4	G. Madu gula	762.0	211.0	15.0	176.0	1,164.0
5	MunchingTut	785.0	197.0	8.0	170.0	1,160.0
6	Pedabaval u	780.0	229.0	8.0	177.0	1.194.0
7	Hukumpeta	772.0	241.0	9.0	178-0	1,200.0

Sr. No	Mean Seasonal Rainfall					
	Station	**Southwest monsoon (A)**	**Retreating monsoon (B)**	**Winter season (C)**	**Summer season (D)**	**Mean annual rainfall**
8	Araku	8004	235.0	9.1	220.3	1,264.8
9	Ananta.,Iri	745.0	241.0	15.0	170.0	1,171.0
10	Dumbriguda	786.0	235.0	8.0	195.0	1,224.0
11	Madugula	703.0	281.0	21.0	159.0	1,094.4
12	Narsipatnam	676.2	281.9	27.1	180.4	1,165.6
13	Rolugunta	705.0	307.0	26.0	160.0	1,198.0
14	Kotauratla	605.0	283.0	27.0	110.0	1,165.6
15	Makavarapalem	633.0	287.0	28.0 0	141.0	1,089.0
16	Nathavaram	730.0	274.4	18.0	144.0	1,166.0
17	K. Kotapadu	635.0	283.0	25.0	121.0	1,064.4
18	Chodavaram	630.9	284.8	24.7	124.0	1,064.4
19	Butchiahpeta	648.0	296.0	23.0	130.0	1,097.0
20	Padmanabham	595.0	302.0	28.0	93.0	1,018.0
21	Kasimkota	560.0	300.0	27.0	100.0	987.0
22	Subbavaram	585.0	303.0	26.0	94.0	996.1
23	Paravada	545.0	311.0	28.0	77.0	961.0
24	Pendurthi	570.0	304.0	27.0	82.0	948.0
25	Anandapuram	552.0	309.0	28.0	85.0	974.0
26	Elamanchili	533.1	296.3	28.7	110.4	958.5
27	Atachuthapuram	529.0	320.0	28.0	76.0	953.0
28	Anakapalli	579.6	294.9	26.3	95.3	996.1
29	Bheemunipatnam	514.4	330.3	30.0	84.0	951.5
30	Visakhapatnam	521.0	323.9	27.8	75.3	954.3

Table 1.3(A): Distribution Soils in Visakhapatnam District

Sr. No:	Name of the Mandals	Predominant Soils (%)		
		Sandy Loam	Red Loamy	Black Cotton
1	Chinthapalli	0	92	0
2	Paderu	0	55	40
3	G.Madugula	0	100	0
4	Munching put	0	100	0
5	Pedabayulu	0	84	0
6	Araku	0	78	0
7	Ananthagiri	0	95	0
8	Koyyuru	60	29	0
9	Madugula	69	0	0
10	Narsipatnam	40	36	0
11	Kotauratla	0	100	0
12	K.Kotapadu	40	0	40
13	Sabbavaram	0	72	0
14	Ravikamatham	40	45	0
15	Pendurthi	0	84	0
16	Nakkapalli	0	84	0
17	Elamanchili	40	36	0
18	Kasimkota	0	52	0
19	Bhemunipatnam	36	61	0

Table 1.3(B): Fertility Index of Soils

Sr. No	Stations	Organic Carbon (OC)		Phosphorous ($P_2o^{5)}$		Potassium (K_2o)	
		1998	2009	1998	2009	1998	2009
1	**Hilly region**						
	Ananthagiri	1.42	1.15	1.90	1.63	2.67	2.57
	Paderu	1.15	1.14	2.42	1.57	3.00	2.38
	Chinthapalli	1.01	1.00	1.65	1.09	2.96	2.83
2	**Interior Plains**						
	Narsipatnam	1.40	1.03	1.87	1.57	2.46	2.82
	Chodavaram	1.07	1.16	2.65	2.25	3.0	2.29

Sr. No	Stations	Organic Carbon (OC)		Phosphorous ($P_2o^{5)}$		Potassium (K_2o)	
		1998	2009	1998	2009	1998	2009
3	**Coastal Plains**						
	Elamanchili	1.16	1.09	2.76	2.24	2.96	2.38
	Anakapalli	1.47	1.11	2.57	2.48	2.87	2.16
	Visakhapatnam	1.42	1.11	2.67	2.45	2.96	2.32

(Source: Soil Testing Laboratory & Dept of Agriculture Research Centre, Anakapalli, Visakhapatnam District)

Limits: Low Fertility <1.16
Medium Fertility 1.16 to 2.33
High Fertility >2.33

Table 1.4: MAJOR AND MEDIUM IRRIGATION SOURCES-2007-2008

(Area in Hectares)

Sr. No	Irrigation Source	Name of the Project	Actual Net Area Irrigated
1	**Major Irrigation**		
2	**Medium Irrigation**	a) Thandava Reservoir	15896
		b) Konam Reservoir	4931
		c) Raiwada Resrvoir	6074
		d) Kalyanapulova Reservoir	2113
		e) Padderu reservoir	7819
3	**Minor Irrigation**	a) Ravanapalli Reservoir	1053
		b) Gambheeram gedda Reservoir	104
		c) Seshugedda	101
		d) N T R Reservoir	809
		e) Rangabolugedda Reservoir	144

(Source: Irrigation Department, Visakhapatnam.)

Table 1.5(A): STANDARDS FOR DRINKING WATER

Parameter	ISI		WHO	
	Permissible	Excessive	Permissible	Excessive
pH value	6.5-8.5	6.5-9.2	7.0-8.5	6.5-9.2
TDS	500	2000	500	1500
Hardness	300	600	--	--
Chloride	250	1000	200	600
Fluoride	1.0	1.5	1.5	--
Calcium	75	200	75	200
Magnesium	30	100	50	150

Table 1.5 (B): Physico- Chemical Characteristics of Ground Water Samples in Visakhapatnam District

Samples	Hilly Region	Interior Plains	Coastal Plains
pH Value	8.4	8.1	8.6
TDS	133	380	413
Hardness	153	440	340
Chloride	14	140	65
Fluoride	0.1	0.1	0.3
Calcium	45	60	74
Magnesium	16	70	55

Table 1.6: AVERAGE DEPTHS OF WATER LEVELS (meters)

Years	Hilly Region		Interior Plains and Uplands		Costal Plains	
	Pre-monsoon (May)	Post-monsoon (Nov)	Pre-monsoon (May)	Post-monsoon (Nov)	Pre-monsoon (May)	Post-monsoon (Nov)
1989	10.85	6.69	5.37	2.87	4.6	2.7
2009	11.13	9.32	5.6	3.67	5.7	3.8

Source: Ground Water Board, Visakhapatnam District.

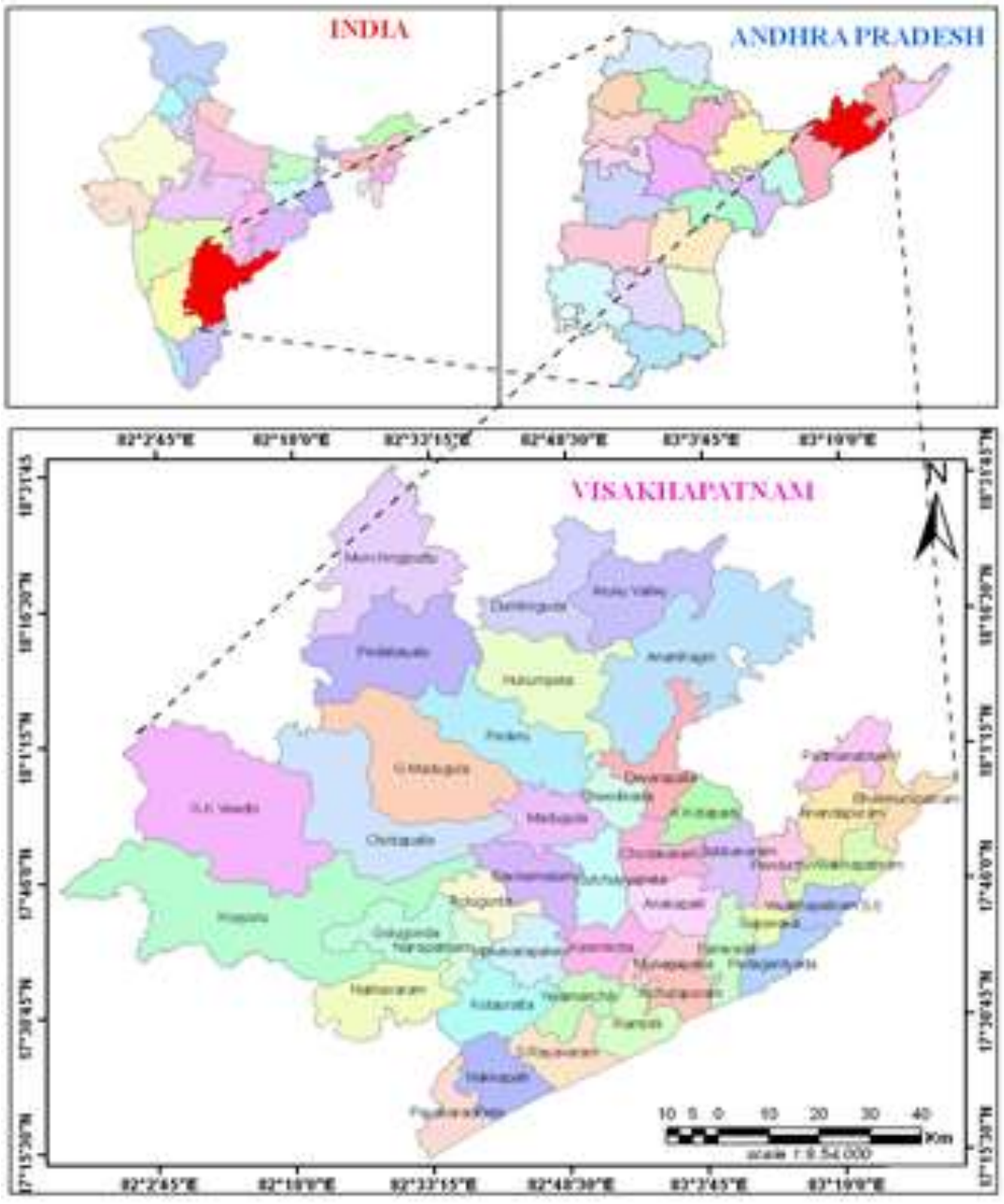
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Figure 1.2: Visakhapatnam district-locations of rain gauge stations

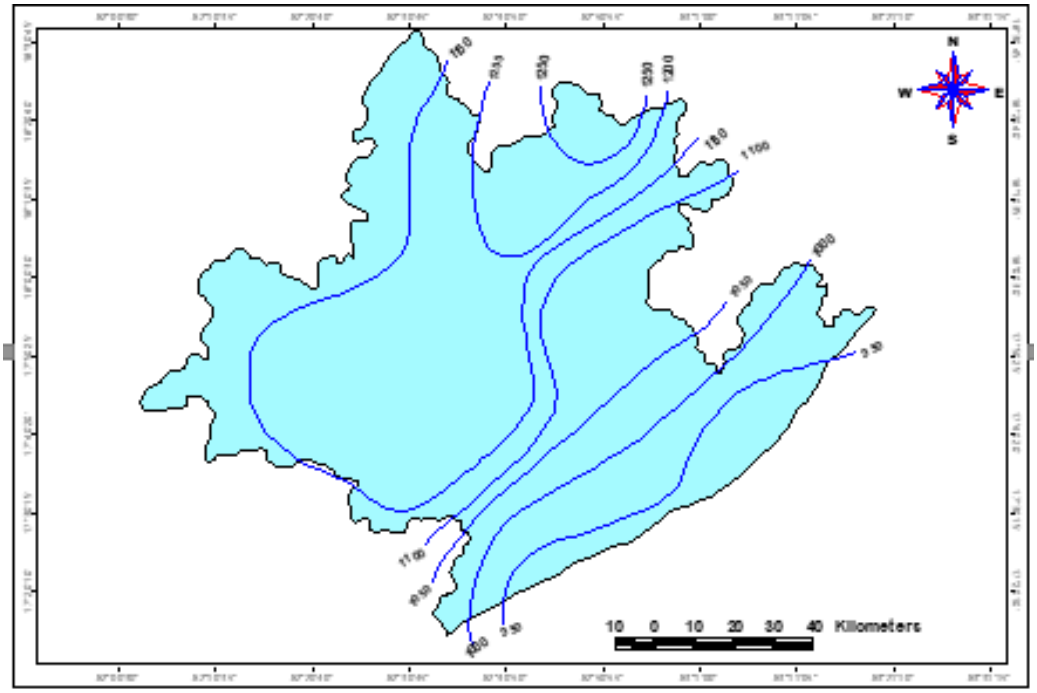

Figure 1.3: Mean Annual Rainfall (mm)

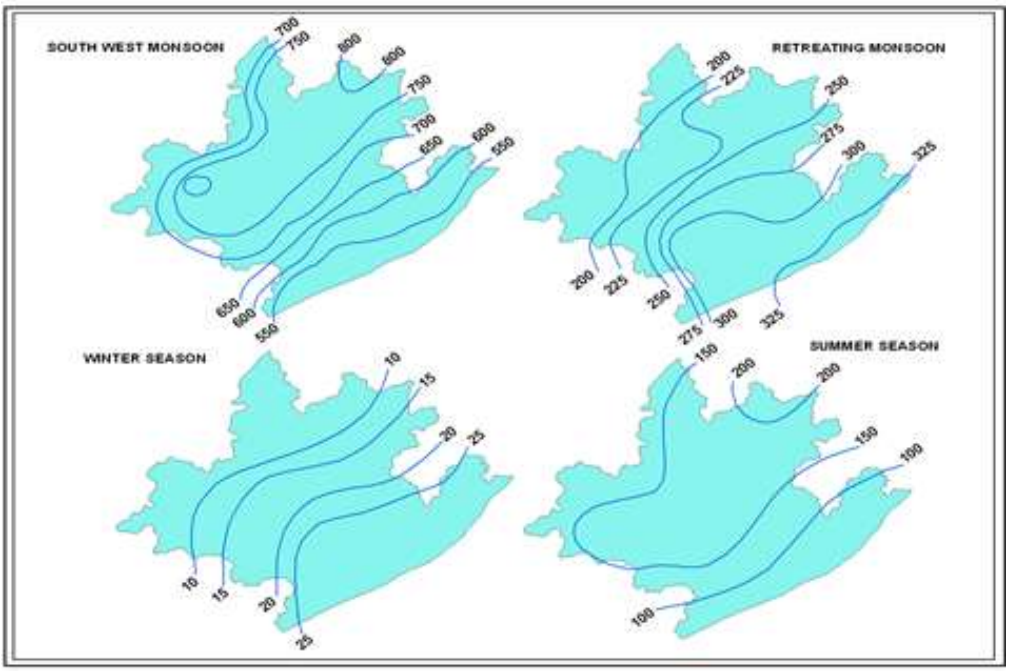

Figure 1.4: Mean Seasonal Rainfall (mm)

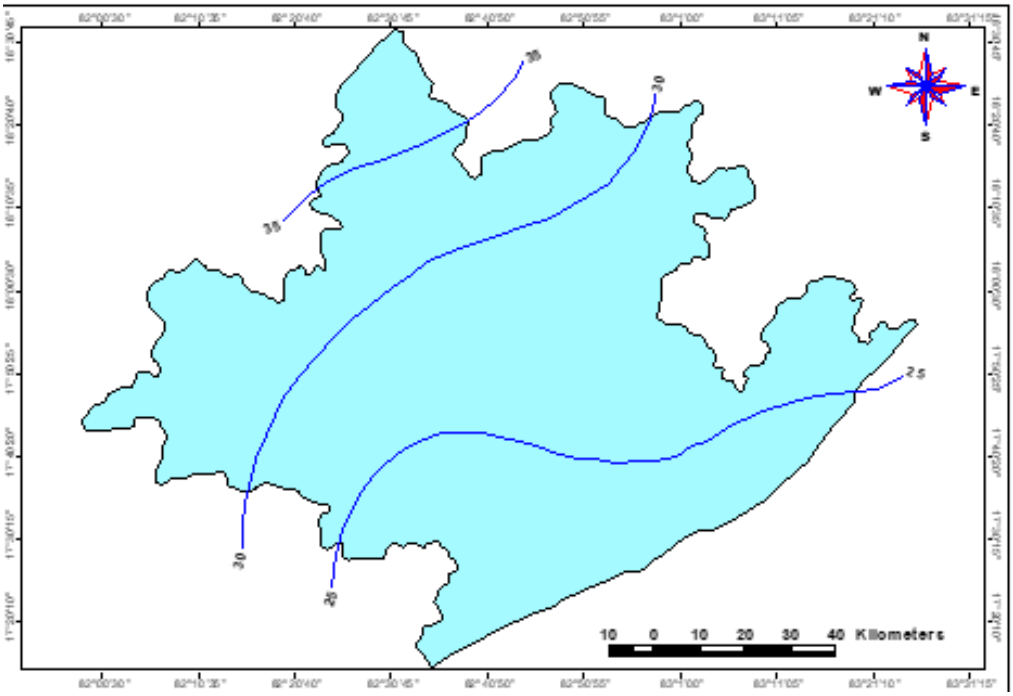

Figure 1.5: Annual Variability of Rainfall (%)

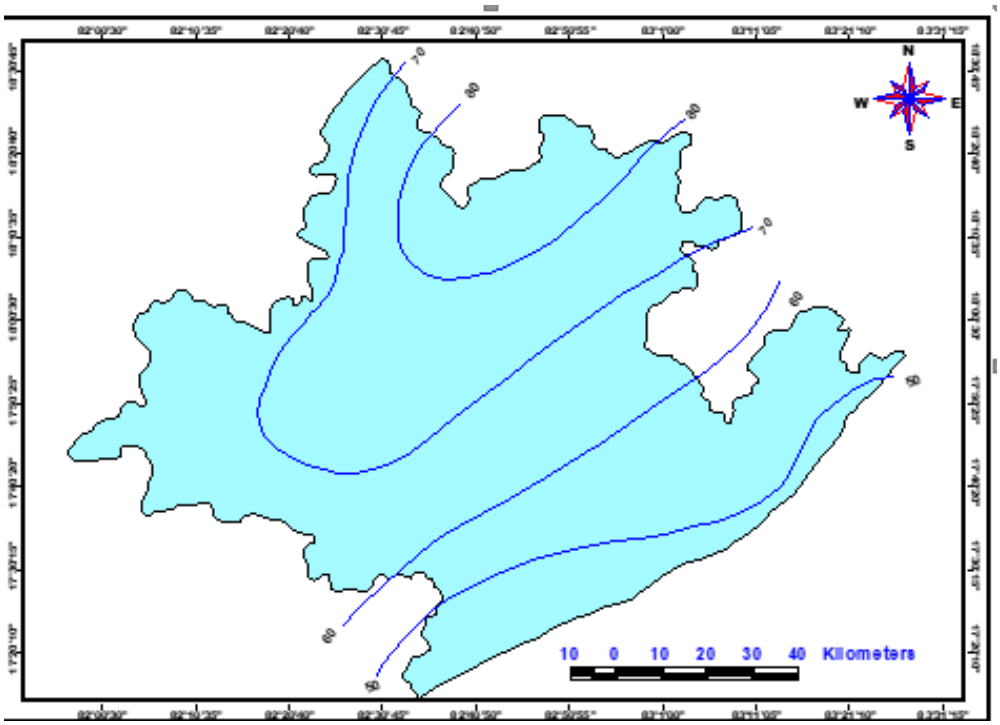

Figure 1.6: Mean Annual Rainy days

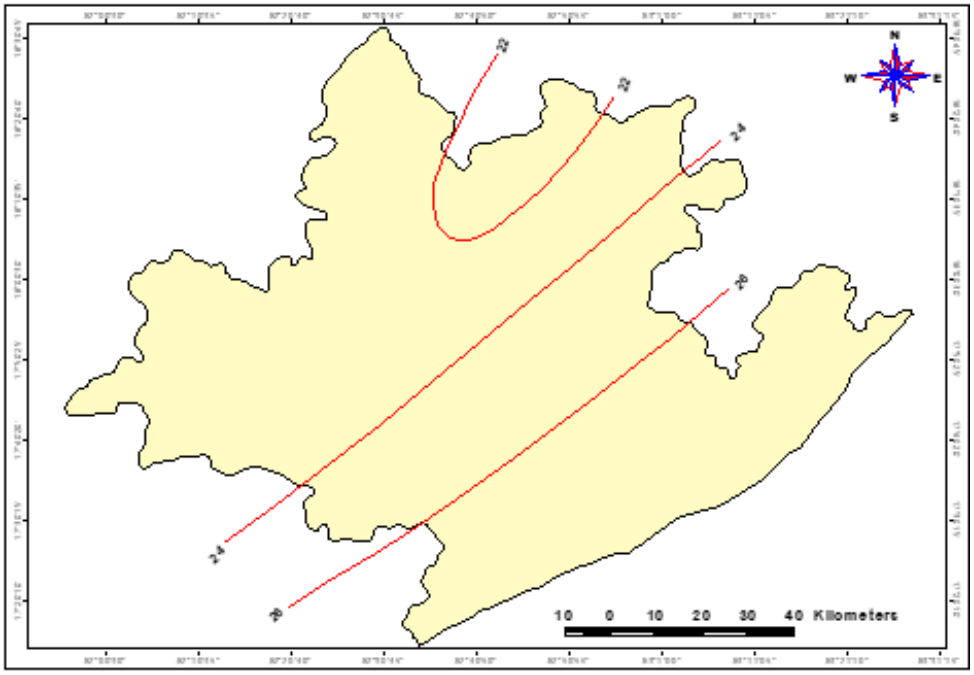

Figure 1.7: Mean Annual Temperature (°C)

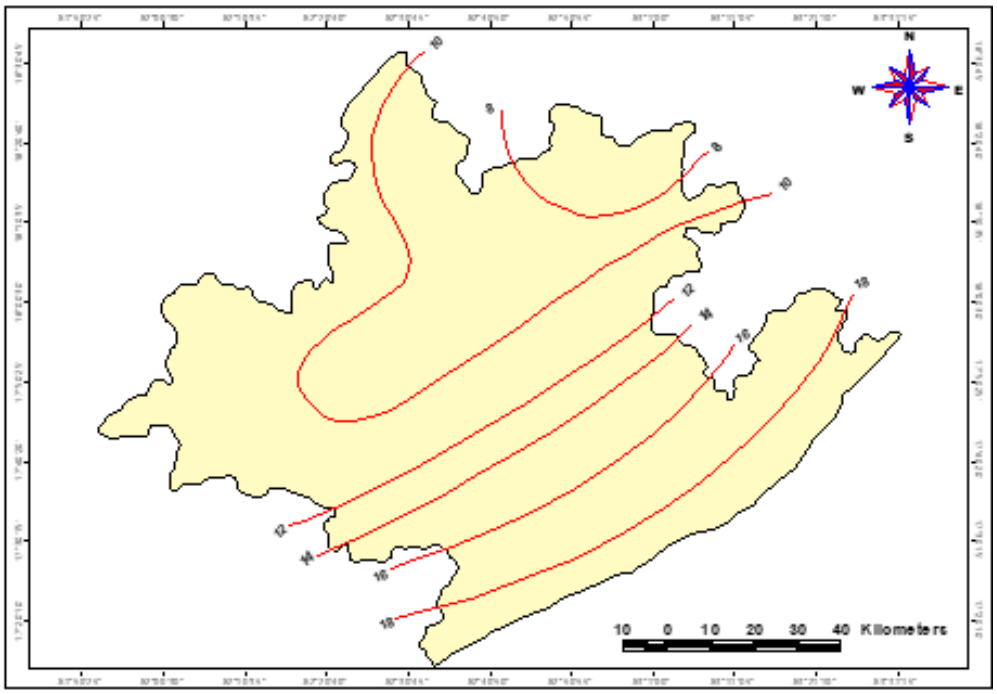

Figure 1.8: Mean Minimum Temperature of the Coldest Month (°C)

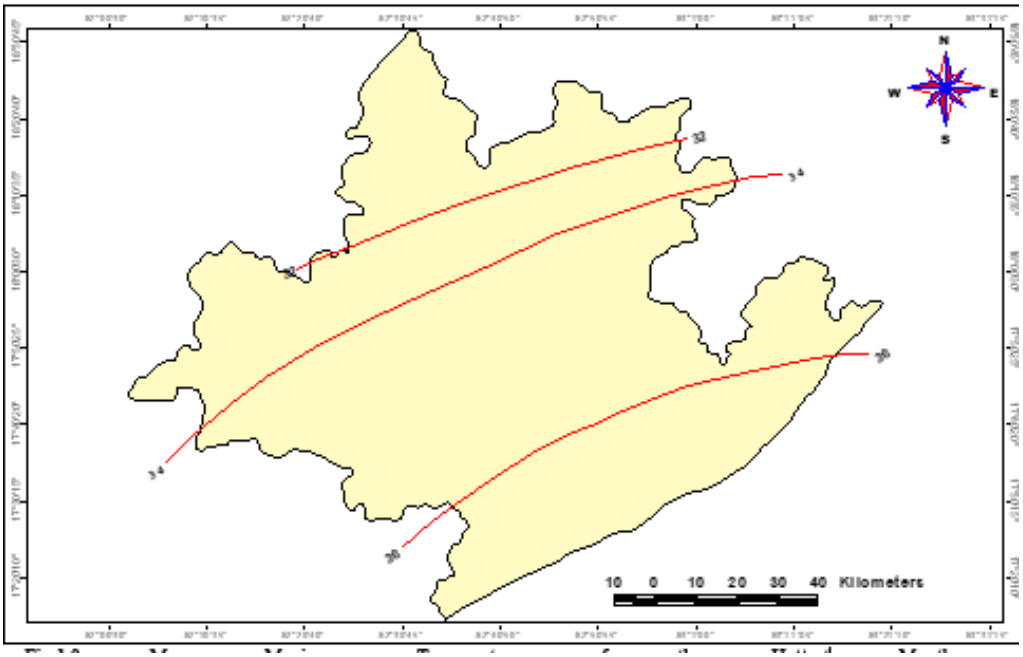

Figure 1.9: Mean Maximum Temperature of the Hottest Month (°C)

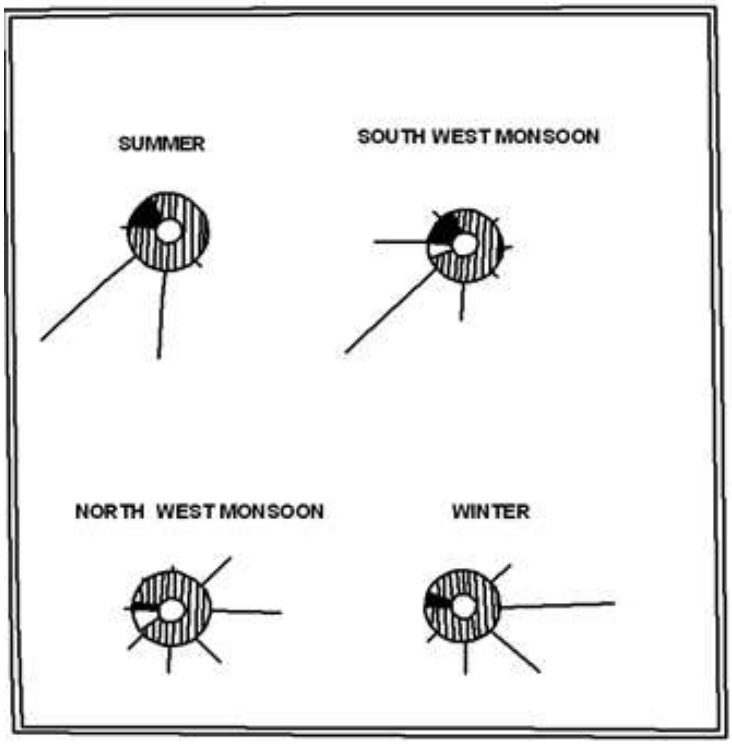

Figure 1.10: Visakhapatnam – Wind Roses

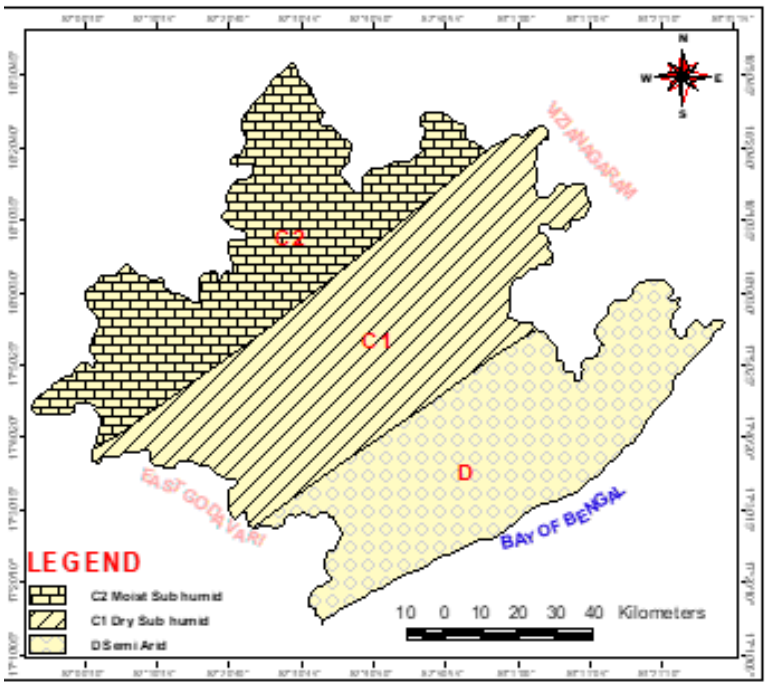

Figure 1.11: Climate Types (As per moisture index of Thornthwaite)

6.7 Tables & Figures Captions:

Table 1.1: Temporal variation of Land utilization and changes in percentage of land with respect to total geographical area in Visakhapatnam district during 1987-98 and 2007-2008.

Table 1.2: Indicates the mean seasonal and Annual Rainfall (mm) rainfall during the A). South west monsoon, B). Retreating monsoon, C). Winter Monsoon, D). Summer Monsoon of the Visakhapatnam District through cyclone warning centre, Visakhapatnam.

Table 1.3(A): The table indicates the percentage Distribution soils (sandy loam, red loamy, black cotton) at 19 mandels at Visakhapatnam district.

Table 1.3 (B): Fertility Index of Soils: This table indicates the concentration of fertility index of soils like Organic carbon (OC), Phosphorous (P_2O^5), Potassium (K_2O) at three stations 1). Hilly region, 2). Interior Plains, 3). Coastal Plains during 1998-2009 periods.

Table 1.4: This table indicates the major projects were conducted for three irrigation resources 1). Major 2). Medium 3). Manor for the area of land in hectares during 2007-2008.

Table 1.5 (A): This table indicates the Standards chemical (Permissible/excessive) concentration for Drinking Water from ISI and WHO (World Health Organization, Geniva)

Table 1.5 (B): This table indicates the Physico-m Chemical Characteristics of the ground water sample at 1). Hilly region 2). Interior Plains, 3). Coastal Plains in Visakhapatnam District.

Table 1.6: This table indicates the Average Depths of Water Levels (Meters), at pre-monsoon and post monsoon seasons during 1989-2009 periods, over 1). Hilly region, 2). Interior Plains and Uplands, 3). Coastal Plains.

Figures Captions:

Figure 1.1 The pie diagram indicates Land utilization in Visakhapatnam district Green color indicates the Forest land, Yellow color indicates the Net area sown, grey colure indicates the barren and unculturable land, merin color indicates the land put Non- Agriculture uses etc. In this diagram East Godavari district located at South-West direction and Vizianagaram located at North-East direction, Odessa located West to North –East direction.

Figure 1.2 This figure indicates the locations of rain gauge stations including 42 mandals in Visakhapatnam District, Right side down scale indicates in map one unit Equal to one kilometer in ground. The upper right symbol indicates the Map directions of the Figure.

Figure 1.3. This figure indicates Mean Annual Rainfall (mm) including 42 mandals in Visakhapatnam District, Right side down scale indicates in map one unit Equal to one

kilometer in ground. The upper right symbol indicates the Map directions of the Figure. The blue color lines indicate annual Isopitches (equal rainfall lines) in (mm).

Figure 1.4 Indicates the seasonal (monthly) rainfall (mm/month) variability during. Summer winter treating monsoon seasons over Visakhapatnam district. The blue lines indicates the (isohyets) over district.

Figure 1.5 indicates the annual (yearly)-(mm/year) variability of rainfall over Visakhapatnam district. From 2008-2009, one unit shows in ground one kilometer.

Figure 1.6 the Mean annual rainy days from 2008-2009 one unit over the ground indicates one kilometer. Upper right symbol indicates the direction of the Map.

Figure 1.7 Figure indicates mean annual temperature (^{0}C) over the Visakhapatnam district the red lines indicates isothermal lines. One unit shows in ground one kilometer. one unit over the ground indicates one kilometer. Upper right symbol indicates the direction of the Map.

Figure 1.8 Indicates the mean minimum temperature of the coldest month(December) (^{0}C) the red lines shows isothermal lines over the district. one unit over the ground indicates one kilometer. Upper right symbol indicates the direction of the Map.

Figure 1.9 Mean Maximum temperature of the hottest month (May) the red lines indicates the isothermal lines over the district. one unit over the ground indicates one kilometer. Upper right symbol indicates the direction of the Map.

Figure 1.10 Wind rose are) Summer 2) Winter 3) South-west 4) north-east monsoon.

Figure 1.11 This figure indicates the climate types (As per moisture index of Thornthwaite) C1 -Dry sub humid, C2- Moist sub Humid, D-Semi-arid