GEOGRAPHICAL STUDY OF IMPACT OF CLIMATE CHANGE ONAGRICULTURAL PRODUCTIVITY INANDHRA PRADESH

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Principal Investigator: Prof. A.V.SHASHIKALA

PROF. A.V. SHASHIKALA
DEPARTMENT OF GEOGRAPHY & GEOINFORMATICS
OSMANIA UNIVERSITY
HYDERABAD
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GEOGRAPHICAL STUDY OF IMPACT OF CLIMATE CHANGE ON AGRICULTURAL PRODUCTIVITY

A Case Study of Andhra Pradesh

IN BRIEF

Weather and Climate are the most important factors affecting the Agriculture. As agriculture gets affected so the productivity. Hence thereof researches, experiments and finding alternative solutions are required. Sometimes we need to change the usual practice in order to meet the demand and to cope with the changed environment. Here the case study describes...

PROF. A. V. SHASHIKALA
M. A., M. Phil, PhD.
DEPARTMENT OF GEOGRAPHY
OSMANIA UNIVERSITY
HYDERABAD.

PREFACE

Climates have changed in the past and will continue to change over in the future.Along with crustal evolution of the earth surface, climatic changes were bound to be evidenced due to cumulative impact of terrestrial and extra-terrestrial forces.Eustatic and isostatic impacts of such changes were always felt on the vast geo processes and subsequently on the land use systems.However, in the present anthropogene period particularly in the last few decades the global climatic changes due to human centric activities has become an issue of concern, because of its impact on intensity of temperature and rainfall variations, sea level changes, frequency increase in extreme climatic events like floods and droughts.

All these would definitely have a long-lasting impact on human livelihoods and food security. IPCC has been making vast efforts to understand the causes and consequences of global climatic changes.

The study of such climatic variations in a climatically vulnerable region becomes interesting as it would have direct impact on agrarian economy.Most of Indian peninsula being a rainfed region, the study of rainfall variability assumes significant importance, especially in sensible Agroclimatic Zones.

The present study on **"Geographical Study of Impact of Climate Change on Agricultural Productivity in Andhra Pradesh"** is an attempt to dwell into the above-mentioned theme with a thrust on rainfall and temperature variations in select districts of Andhra Pradesh and Telangana state.With apt and appropriate statistical tools, it is proved that rainfall variability does have an impact on GDP and agricultural production.The author places on record her gratefulness to UGC for funding the successful completion of this two years project.

Dr. S. Padmaja
Prof. Emeritus
Dept. of Geography
Osmania University

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PRINCIPAL INVESTIGATOR
PROF. A. V. SHASHIKALA

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INTRODUCTION

The climate change is inevitable on the earth surface.From prehistoric times to the present-day climates have been changing and will change in future too.The fluctuating alternate warm and cold phases have been the character of the earth surface.Paleozoic, Permo Carboniferous and Pleistocene cold climates have had an everlasting impact on the surface of the earth, the evidences of which are well documented closer to the present day, in the late Pleistocene and Holocene, the climate change has been in a short interval of time.The last glacial period began about 110,000 years ago and ended between 10,000 and 15,000 before the present (around 12,500 years ago).Even during that period there were several changes with glacier advance and retreat.The maximum extent of glaciations, also called last glacial maxima (LGM) was approximately 18,000 years ago.At present it is evident that we are in inter glacial period, as we find evidence of glacial retreat. The present debate on climate change is in progress and the causes and consequences are widely proclaimed to initiate global policy formulations.At present we are in the midst of such changes.

The climate system is a complex interactive system consisting of the atmosphere, hydrosphere, lithosphere, cryosphere and outer space. A recent report (2007) of the intergovernmental panel on climate change (IPCC) has clearly indicated that the earth's climate is changing.In order to show the climate change, several studies have chosen temperature and rainfall as primary parameters.

The studies also conducted by the international Geosphere and Biosphere Programme (IGBP) under various projects reveal that the planet earth has always undergone major changes.The geometry of the earth's orbit introduces regular changes in illumination conditions and thereby stimulates the ice ages.Changes are a natural property of the earth system, but there is mounting evidence that the changes which have been imposed on the earth system during the last 150 years cannot be compared with any previous change.In the last century humankind has driven the greenhouse gas concentrations on earth far beyond the maxima reached during the last one million years has become responsible for 70 % of nitrogen and 95 % of phosphorous cycle on earth and has reduced tropical forest area by 50 %.

Anthropogenic factors have become the most dominant environmental force, notably after the industrial revolution, that a new geological era Anthropocene, has been proposed to describe the last few hundred years. Increased population growth together with accelerated human activities and economic wealth over the past century have greatly increased the resource use as reflected in agriculture, fisheries, forestry, industry, transport, energy and urbanization.This has resulted in multiple and interacting global environmental impacts as seen by the current values of greenhouse gases temperature.

GLOBAL WARMING:

Beginning with the industrial revolution in the 1850's and accelerating ever since the human consumption of fossil fuels has elevated CO_2 levels from a

concentration of 280 PPM to more than 380 PPM today.These increases are projected to reach more than 560 PPM before the end of 21st century.It is known that CO_2 levels are substantially higher now than at any time in the last 8,00,000 years.Along with rising methane levels, these changes are anticipated to cause an increase of 1.4^0Cto 5.6^0C between 1990 – 2100.

For the last three decades, it has been observed that the global average atmospheric temperature is increasing at a high pace.The global average surface temperature has increased by 0.6 ± 0.2^0C since the late 19th Century is further likely to rise by 1.1 to 6.4^0C by the end of 21st century.It is now universally accepted that human induced greenhouse gas emissions are responsible for global surface temperature.Further it is also being debated that abrupt cooling due to glacier melting and prolonged sunspot minima is also expected.Severe winters are witnessed in Europe and North America. Peru has been experiencing floods and Mumbai's march temperature is 40^0C.

INDIAN SCENARIO:

Climate change concerns in India include the rising temperature, projected pattern of precipitation its intensity frequency and enhanced incidences and intensity of extreme events such as cyclones, flash heavy rains, droughts and frequent floods.With a rapidly expanding economy many changes are taking place in India today.Land use, cropping and water use patterns are changing, partly as response to changing investment scenarios and economic growth.

Various studies about climate changes using Global Climate Models (GCMs) and Regional Climate Models (RCMs) over India during the 21st century indicate changing patterns of Rainfall and an increase in temperature.Utility of precipitation primarily depends upon its spatial as well as temporal distribution.Uniform precipitation over a larger area is more useful than its occurrence over a smaller region.Also, precipitation occurring over a larger time period would be more effectively utilized rather than when it occurs within a short span of time.Therefore, projected changes in precipitation patterns over the Indian subcontinent in near future would result in deterioration of water resources.First, decrease in winter precipitation would reduce the total seasonal precipitation being received during December – February, implying greater water stress during the lean monsoon period.Secondly, intense rain occurring over fewer days besides causing increased frequency of floods during the monsoon season, will also mean that much of the monsoon rain would be lost as direct run off resulting in reduced Ground water recharging potential.

(Projected climate change during present century over India has been given in the following table).

Table No. 1.1: Projected Climate Change during Present Century over India

Region	Temperature	Rainfall	Reference
All- India	Increase in winter temperature by 1-4^{0}C with increased CO_2 concentration	Precipitation increase of approximately 20 per cent Increase in heavy rainfall days during the summer monsoon period and an increased inter-annual variability	Bhaskaran, B. et al.
All -India	Average temperature change is predicted to be in the range of 2.33 to 4.78^{0}C with a doubling in CO_2 concentration	Increase in frequency of heavy rainfall events	Lonergan, S.
All -India	Area-averaged annual mean surface temperature rise is projected to range between 3.5 and 5.5^{0}C by the end of the century. More warming in winter season	Increase of about 7 to 10 per cent in annual mean precipitation Decline of 5-25 per cent in winter precipitation Increase in monsoon precipitation is 10-15 per cent Monsoon season over northwest India – increase of 30 per cent or more in rainfall by 2050 Western semi-arid regions of India could receive higher than normal rainfall in a warmer atmosphere Decrease in winter precipitation between 10 and 20 per cent over central India by 2050	Lal M. et al.
All – India	Over the region south of 25^{0}N (south of cities such as Udaipur. Khajuraho and Varanasi), maximum temperature will be increase by 2-4^{0}C during 2050s. In the northern region, increase in maximum temperature may exceed 4^{0}C. A general increase in minimum temperature up to 4^{0}C all over the country	Decrease in number of rainy days over a major part of the country. This decrease is more in the western and central parts (by more than 15 days), while near the foothills of the Himalayas (Uttaranchal) and in northeast India, the number of rainy days may increase by 5-10 days. Increase in rainy days intensity by 1-4 mm/day, except for small areas in northwest India, where rainfall intensities may decrease by 1 mm/day.	Rupakumar K. et al.

Source: Adopted from R. K. Mall *et al., Current Science*, Vol.90, No. 12, 25 June, 2006.

The Rainfall data from 1951 – 2008 reveal that the frequency of sudden rainfall had increased by 10% in India.Incidence of flash floods may increase in coming years because of the impact of climate on the monsoonal system.Extremes of Rainfall and temperature are on the rise.Decrease in number of rainy days but increase in rainfall intensity has been witnessed during the past decade.Variability in the data of onset of monsoon is expected to be higher. With 1.3 mm per year rise in sea level higher flood risks with storm surges are expected in near future.

INDIAN AGRICULTURE AND CLIMATE CHANGE:

Agriculture sector alone represents 35 per cent of India's Gross National Product (GNP), plays a crucial role in the country's development and shall continue to occupy an important place in the national economy. It sustains the livelihood of nearly 70% of the population. It seems obvious that any significant change in climate on a global scale will impact local agriculture, and therefore affect the world's food supply. Changes in the temperature, solar radiation, and precipitation will have an effect on crop productivity, livestock and agriculture. Climate change will also have an

economic impact on agriculture, including changes in farm profitability, prices, supply, demand, trade and regional comparative advantages. The magnitude and geographical distribution of such climate induced changes may affect our ability to expand the food production area as required to feed the burgeoning population of more than 10,000 million people projected for the middle of the next century.

Agriculture is sensitive to short-term changes in weather and to seasonal, annual and long-term variations in climate. For the long-term changes, agriculture is able to tolerate moderate variations in the climatic mean. Changes beyond these bands of tolerance may require shifts in cultivators and crops, new technologies and infrastructure or ultimately conversion to different land uses. Crop yield is the culmination of a diversified range of factors. The variations in the meteorological parameters are more of transitory in nature and have paramount influence on the agricultural systems, although other parameters, like soil characteristic, seed genetics, pest and disease and agronomic practices also do impact crop yields. Among these factors, pest and diseases cause a significant loss to world food production under different climatic conditions. Development and distribution of pest and diseases are governed by temperature patterns, rainfall or humidity and seasonal length to a great extent. Especially, winter temperatures are important for the survival of pest and studies have shown that increase in temperature accelerates the development of pests in general. Pest-crop interaction will be also directly affected by the rising CO_2 levels through the alteration of host plant attributes, such as C/N ratios and secondary plant nutrient chemistry. In terms of crop production, these fluctuations must be taken into the account while planning agricultural operations. The climate elements which affect the plant growth and development (agriculture as a whole) are carbon dioxide concentration, temperature, radiation, precipitation and humidity.

Analysis of the food grains production/productivity data for the last few decades reveals a tremendous increase in yield, but it appears that negative impact of vagaries of monsoon has been large throughout the period. In this context, a number of questions need to be addressed as to determine the nature of variability of important weather events, particularly the rainfall received in a season/year as well its distribution within the season. These observations need to be coupled to management practices, which are tailored to the climate variability of the region, such as optimal time of sowing, level of pesticides and fertilizer application.

The mean temperature in India is projected to increase by 0.1–0.3°C in kharif and 0.3–0.7°C during rabi by 2010 and by 0.4–2.0°C during kharif and to 1.1–4.5°C in rabi by 2070. Similarly, mean rainfall is projected not to change by 2010, but to increase by up to 10% during kharif and rabi by 2070. At the same time, there is an increased possibility of climate extremes, such as the timing of onset of monsoon, intensities and frequencies of drought and floods.

It is forecasted that a strong linear decline in wheat and rice yield was noticed with the increase in January temperature.Sinha and Swaminathan (1991) reported that

a 2^0C increase in mean air temperature could decrease rice yield by about 0.75 t/ha in the high yield areas and by about 0.06 t/ha in the low yield coastal regions.

Agarwal and Kalra (1994) demonstrated the shift of iso-yield lines of wheat in India with 425 PPM of Co2 concentration and 2^0C rise in temperature.A Number of simulation models by Gadgil (1999) Lal etal Mandal (1998), Chatterji and Sahoo have indicated changes in crop yields for crops like Maize, Groundnut, Soyabeen and Chickpea.

Soil productivity too gets impacted by climatic changes.The most important process is the accelerated decomposition of organic matter, which releases the nutrients in short run, but may reduce the fertility in the long run.Soil temperature influences the rates at which organic matter decompose nutrients are released and taken up and plant metabolic processes proceed.Climate change could increase rates of soil erosion, further hampering food production.

The global warming may affect growth and development of all organisms including insect pests.Among all the abiotic factors, temperature along with humidity is the most important one affecting insect distribution and abundance in time and space since these are cold blooded animals.The insects cannot regulate their body temperature and there by ambient temperature influences their survival, growth, development and reproduction.Any small change in temperature can result in changed virulence as well as appearance of new pests, like wise crop-weed competition may be affected, depending upon their growth behaviors.

The following scenarios can be visualized regarding impact of climate change on pest dynamics

1. With an increase in concentration of CO_2, the nutritional status of crop will change and the net effect on agricultural production will depend upon interaction between pests and crops.

2. Gradual climate warming will lead to changes in the composition of pest fauna in different areas.The high population growth rate of many species will ensure changes in pest distribution.

3. If the rise in winter temperature takes place, the duration of hibernation of pests may decrease, thus increasing their activity.

4. Uncongenial areas for pests due to low temperature at present may become suitable due to rise in temperature.

From socio-economic angle, it can be revealed that a warming scenario of $+2^0$C rises in mean temperature and +7% increase in mean precipitation levels will create reduction in the net revenues. (Khan SA et al 2009)

Impact of climate change is high in rain fed regions resulting in lesser yields and revenues, subsequently making small marginal farmers more vulnerable.Growth and instability in yield are witnessed in major crops like sorghum, cotton, wheat (Ashalata K.V. 2012).Rainfed regions may lose farm level net revenue by 9.25%.Indian agriculture is likely to suffer losses in long run due to heat, erratic weather and decreased irrigation availability (Suryavanshi et al 2012).A study at Agricultural University, Rajendra Nagar reveals that with an elevated temperature by 1^0C and 2^0C increased the number of days to attain an-thesis, maturity and decreased the grain yield by 7.3 and 13.7% under normal planting date.Grain yield increased when Co2 increased to 450 PPM and 600 PPM.The reduced solar radiation did not show much influence on growth yield (Raji Reddy et al) (Sudha Rani et al 2011).

CROP PRODUCTIVITY

Increase in atmospheric carbon dioxide has a fertilization effect on crops with C_3 photosynthetic pathway and thus, promotes their growth and productivity. On the other hand, an increase in temperature, depending upon the current ambient temperature, can reduce crop duration, increase crop respiration, alter photosynthetic partitioning to economic products, effect the survival and distributions of pest populations thus developing new equilibrium between crops and pests, hasten nutrient mineralization in soils, decrease fertilizer use efficiency, and increase evapo-transpiration. Indirectly, there may be considerable effects on land use pattern due to availability of irrigation water, frequency and intensity of inter- and intra-seasonal droughts and floods, and availability of energy. All of these can have tremendous impact on agricultural production and hence, food security of any region.

With a rapid increase in global population and more crucially with a corresponding increase in the affluent middle class with high per capita consumption, the emissions of toxic greenhouse gases continue to rise.The effect of the increased emissions of these gases is a drastic change in the weather system and a perturbed rainfall pattern.This sort of climate change leads to concerns about food security, adequacy of water recourses and energy consumption.Through experience we know that climate greatly influences agricultural productivity.Farmers are forced to adapt to the local climate by adhering to established infrastructure, local farming practice and experience got from individual practice.In India nearly 700 million rural people depend directly on climate for their livelihoods in agriculture, forestry and fisheries.They rely on natural resources – such as water, biodiversity, mangroves, coastal zones and grasslands – for their subsistence and economic activity.They are not very competent to adapt themselves to climate change, but a majority of them are being forced to change how they use the resources because of increasingly unreliable rainfalls and rising sea levels climate change sometimes threatens established aspects of farming systems but sometimes also provides opportunities for improvements. A consistent and exhaustive assessment of the direct and indirect effects of climate change on agricultural productivity has not been carried out as yet.A lot of research needs to be done in this area of high uncertainty.The studies that have been

undertaken already, mainly deal with time horizons, analyzing the effects of anthropogenic climate change that could be minimized by reducing greenhouse gas emissions.Research has shown that the temperature of the globe is increasing because the greenhouse gas emissions are not being checked.The effect of the increase in temperature is the melting of glaciers, occurrence of hurricanes and tsunamis, cataclysms and shifting seasons.Yields of desirable crops reduce gradually because of increased temperature and it also encourages weed and pest growth.Because of all these negative influences the impact of climate change on agricultural productivity is going to be disastrous.

THE PROBLEMS OF CLIMATE CHANGE:

The ecological and agricultural landscapes that influence agricultural productivity get altered because of the interaction of natural resources (like land, crop, animals and water), environment and people.These interactions do not happen smoothly if there is a wide fluctuation in climate.Agriculture along with forestry and fisheries provides the primary sources of food and nutritional security for the public.Agriculture is a multi – dimensional and multi-faceted sector that asks for the efficient use of natural resources, productivity enhancement and preservation of the eco systems in a way that can preserve the needs of human livelihood for posterity.If productivity has to increase there should be preservation of the ecosystem and it becomes difficult to preserve the ecosystem if climatic conditions are not conducive.The problem of climate change is pervasive and affects the whole globe which in turn affects agricultural production in the developed and developing countries.The people in the developing world are affected more because there is a greater variety of an agro-ecological zone which makes it more cumbersome to use the natural resources.If we consider the Indian scenario, the poor farmers livelihoods are affected the most because they do not have the capability to uplift themselves from impoverishment.The farmers even now find it very difficult to tailor themselves to the available natural resources and this situation becomes worse when there is a major climatic change.But research indicates that climate change cannot be avoided and this is again a major threat to agriculture and ultimately food supply to mankind.

The impact of climate change is felt across most sections of the Indian economy.Droughts and floods have become more severe.Crop yields have decreased with rising temperatures.However, in certain cases higher CO_2 in the atmosphere has caused greater crop growth and has offset some of the adverse effects of weather change.Severe droughts could lead to greater desertification if land resources are not carefully managed.India's agricultural sector is susceptible to climatic variability including multiple years of low and erratic rainfall.This vulnerability is arriving at a time when a second form of vulnerability is becoming acute: vulnerability to global trends in food prices.With liberalization of Indian trade in agricultural products, economic changes will bring in uneven impacts. Some regions and farmers benefit from market liberalization and inflow of investments and technology; however, others

may have difficulty in adjusting to a more open economy especially to the effects of increasing competition from agricultural import.

Agronomists strongly believe that agricultural productivity will be affected greatly only if there is a rapid climate change.This is because if the climate change is gradual, there will be sufficient time for biota change.Rapid climate change gives very less time for natural selection and adaptation.However sometimes agriculture produces changes in climate by releasing greenhouse gases such as carbon dioxide, methane and nitrous oxide.This alters the Earth's land cover and affects the earth's ability to absorb or reflect heat and light.Land use change such as felling of forest trees and desertification and the increased use of fossil fuels become the major anthropogenic sources of CO_2.The main contributor to increasing methane and nitrous oxide concentrations in the earth's atmosphere is agriculture alone.Although there are technological advances like genetically modified varieties of seeds and organism and irrigation systems, climate still is the most important factor that affects agricultural productivity and trade in agriculture has also grown immensely off late and provides a myriad amount of food at the national level to major importing countries and a good return to the exporting countries.The inter-governmental panel on climate change (IPCC) provides many reports that have studied literature on climate change.They concluded that the poorest countries are the worst hit with reduction in crop yield because of decreased availability of water and insect pest attacks.In India, where poverty is rampant and agriculture is the mainstay, the climate change reduces agricultural yields significantly.This situation to changing climate like higher temperature is not undertaken on a war footing.According to FAO (2006), agriculture makes up 20% of GDP in India and provides employment for nearly 52% and the majority of agricultural workers belonging to the poorer segment of the population.And as mentioned earlier farmers are able to adapt less to climate change due to constraints in credit and no sufficient access to technological advancement.Capital markets are incomplete, there is a very tardy transmission of information and added to this there is a dearth of capital which intensifies the problem of adaptation to new technological practices.Profitable agricultural practices are not adopted and even factors like labor are not that mobile in India.

Because agricultural productivity is being drastically affected by climate change, many farmers are resorting to indigenous practices and community sharing to get over the crisis.In the Balangir district of Odisha many farmers have revived traditional farming practices. One of the farmer's entire Kharif Paddy crop was damaged by irregular rainfall and so in his farm of three acres he grew Gurjee millet.This crop gave him good returns; he could feed his family and also earn additional Rs. 7000 in cash.Gurjee can be harvested in two months and does not require chemical fertilizers.The expenses incurred for crop production was less and the returns that he got was more.However, the other farmers who grew paddy and resorted to the regular cycle incurred heavy losses and also could not overcome food insecurity.This is what can be termed as intelligent smart farming.The Centre for Sustainable Agriculture (CSA) located at Hyderabad is conducting research programmes to investigate the problems forced by farmers due to climate change and

how these farmers are getting over this problem by implementing innovative local farming practices.

In Himachal Pradesh, according to a study conducted by the Indian Council for Agricultural Research (ICAR) apple production has decreased because required low temperatureis increased and farmers are shifting the growing zone to higher elevations.

The Southwest monsoon helps in nearly half of the food grain production and sixty five percent of production of oil seeds in India.Kharif and Rabi are the two major cropping seasons in India.The Kharif season last from May to October and the Rabi season from November to April.The soil from the summer monsoons retains moisture and serves this season in rain fed areas.But because of fluctuation in rainfall, the planting times are changing for both seasons all across India.It is positive that Khairf rainfall is increasing in many parts of India and this is positive for Kharif crops such as rice, Pulses and oil seeds.Even a degree rise in Temperature severely impacts production of wheat in the Rabi season.But when farmers shift the farming time, according to the shift in rainfall patterns this loss is reduced to million tons.Jhalawar district in Rajasthan gets an average rainfall of 943 mm per annum but is very climate sensitive and has very less adaptive capacity.And as observed in Odisha, here also many farmers moved from producing traditional crops such as sorghum and millet to soybean cultivation.For this they were paid better.But because soybean prices fluctuate according to world market prices, the shift towards growing soybean left farmers in Jhalawar susceptible to external market price shock.Soybean cultivation is also very prone to climate change. In the years 2000 – 2004, crop yields reduced drastically because of drought.Some farmers moved to the neighboring state of Gujarat in search of work.Those farmers who took loans from lenders had lot of difficultly in returning it.Economic crisis makes it cumbersome for farmers to adjust to climate changes.

Agricultural productivity is also affected indirectly by climate change. Rising atmospheric Co2 is very favorable for pests.To reduce the mortality rate of aphids and help in the dispersion of those pests, Pathogens and diseases also get affected due to weather change.Sometimes warming causes environmental stress and this induces increased pathogenicity of organism by mutation.In the next twenty years there is a possibility of disease affecting oil seeds and there is also a possibility of it spreading to other regions where the disease was not observed so far.In the decades to come climate could affect agricultural productivity by changing the quantity and quality of crops; by changing agricultural practices through a change in water use and the use of herbicides insecticides and fertilizers; by increasing the frequency and intensity of soil drainage, soil erosion and reduction of crop diversity because of environmental effects; by increasing or decreasing the area of rural cultivated lands brought about by land speculation and renunciation; by adaptation where farmers through experience may create more competitive crop varieties that are resistant to excess water and floods.

In the state of Andhra Pradesh, because of limited rainfalls farmers in the district of Ananthapur began to grow sorghum (Jowar) and seven varieties of millets.Millets started growing well in the arid climate and helped in food security.Pests which attacked other crops did not attack the millet crops as these crops were more pest resistant.Farmers in AP were introduced to ground nuts in the 1970's and this has now become the main cash crop.However, although groundnut helps in nitrogen fixing in soils, planting groundnut alone season after season led to major soil depletion and growth of pests.Unlike millet, groundnut is affected to a larger extent by rainfall pattern.And some farmers in Ananthapur district started resorting to crop rotation.They started sowing drought resistant pulse crops like horse gram in September instead of cultivating groundnut in July and they also started planting beans, redgram, greengram and millets.Pearl and finger millet are a few of the crops that are quite suitable for the type of soil and weather condition in Ananthapur district.These pulse crops are drought resistant, do not require much water and have shorter growing periods.Another big advantage is that the crop residue if dried and stored properly becomes very good fodder for the livestock.

The climate change vulnerability profile of Andhra Pradesh has been assessed using a detailed diagnostic study, using the UNDA methodologies.The study has been undertaken on the basic hypotheses that two important variables affect the climate change vulnerability of region.The first one is the adaptive capacity of the region and the second one is the physical exposure of the region to climatic events.There are some adaptation interventions that can be undertaken to increase agricultural productivity.There are certain issues regarding location of land and availability of water which needs intervention.Lot of land in AP falls in the rain shadow areas and because of this there is acute shortage of water.The farmer's difficulties increase because the level of groundwater reduces further.This can be averted by encouraging water harvesting check dams to be dug out from farms ponds and conservation furrows and thus increasing the percentage of sown area under irrigation. Dependency on canal irrigation should be encouraged and dependency on well irrigation decreased.Further ground water recharge practices should be adopted, and the government should consider sharing of water resources between states, individuals and regions.Another critical crisis that needs intervention is farmers facing debts because of losses incurred due to failure of crops.An alternative to solve this crisis is to diversify crops so that heat and drought resistant varieties can be developed.Research should be carried on in those lines and the government should establish institutional frameworks to maximize incentives for agriculture.Farmers should be made to understand the important of cultivating modified crops and care should be taken to check that these new crops do not disturb the ecological balance.Further tenant farmers should be provided easy access to crop financing.

There should be an excellent coordination between Panchayati Raj institutions, district administrations, state departments and the central government to ensure proper implementation of these adaptation interventions such that crop varieties can be sustained at local levels against climatic variations in Andhra Pradesh.In the state of AP Paddy, Millets and Cotton are the major crops and agriculture plays a very

significant role in its economy.Erratic rainfall in the winter has a negative impact on Rabi crops, so much so in the rain fed areas.Because of the unpredictability of monsoons rain fed agriculture involves a lot of risk. In the year 2008 -2009 the North East monsoon was less by 45% from normal; by 27% in 2006 -2007; and by 45% in 2005 – 2006 etc.In 2008, some of the districts in Andhra Pradesh like Mahabubnagar; Adilabad and Nalgonda had very less rainfall.Rabi crops are also affected by temperature fluctuations.Even one degree rise in temperature reduces wheat production by 4 to 5 million tons.This severely affects crop production in Andhra Pradesh as well.Again, heat wave results in dehydration of plants that cannot be regained by night.This results in defoliation because the reserve carbohydrates get depleted and slows down the production of new leaves and added to this the recovery is very slow.Added to climatic variations, even external factors reduce farm productivity.Power availability for agricultural purposes is very less.The use of tractor and other mechanical devises is very less, and farm power in the state is yet to achieve the targeted level and because of excessive dependency of the power sector on natural climate events there is a lot of crop failure resulting in greater distress for farmers.

The most important issues that affect agricultural productivity in relation to climate change in the state of Andhra Pradesh are

1) A deteriorating impact on winter Rabi-crop in the rain fed areas because of decrease in rainfall.

2) Rabi crops being affected severely because of fluctuations in temperature.

3) Dehydration of crops because of heat waves.

4) Less of rainfall during the south-west monsoon resulting in a reduction of crop area.

5) Heavy rains or scanty rains causing a lot of risk for agriculture dependent on rains.

6) Soil erosion and heavy loss of rainwater due to deforestation.

7) Many districts in the state like Ananthapur, Kurnool, Kadapa, West Guntur, East Mahaboobnagar, Prakasam, Nalgonda etc., being dry lands where the rainfall for the whole year is less than 550 mm and because the land is infertile it is not suitable for agricultural production.

8) Because of unregulated use of pesticides and fertilizers, there is loss of arability of soil.

Prior to the State bifurcation the state of Andhra Pradesh was divided into three regions (1) **Coastal Andhra** (2)**Telangana** (3) **Rayalaseema.**

More than 75% of canal irrigation is available to Coastal Andhra followed by 17% in Telangana and 7.5% in Rayalaseema.Agricultural productivity in Telangana and Rayalaseema was neglected.Bore well and dug well irrigation increased in the Telangana and Rayalaseema regions and this resulted in the depletion of water table in these regions.The ratio of fallow lands is increasing and this is causing reduction in the net cultivated area.The state is experiencing decrease in growth rate of agricultural sector resulting in decline of employment in rural areas.This is causing mass public movement to urban areas especially from backward districts like Mahabubnagar, Medak, Nalgonda, Warangal, Ananthapur,Chittoor and Vizianagaram.There is a decline of institutional finance to the agricultural sector and the role of money lenders is still significant in Telangana and Rayalaseema regions.Therefore, agriculture must be given top priority along with infrastructive development in backward regions.Construction of flood flow canals like Ichampally and Polavaram irrigation projects across river Godavari would benefit north Telangana and north Coastal districts, and the proper utilization of Krishna river water will benefit Nalgonda, Mahabubnagar and Kurnool districts in south Telangana and Rayalaseema.Distribution of cultivable public lands, surplus lands and cultivable waste lands among the poor of rural areas would provide some solution to the agricultural farmers.The cropping pattern in drought prone areas of the three regions needs to be changed to prevent further reduction of underground water table. The excessive dependency of farmers and rural artisans on money lenders and private financiers can be reduced by increasing rural and agricultural credit facilities.

AGRO CLIMATIC ZONES OF ANDHRA PRADESH AND THEIR CHARACTERISTICS:

The cropped area in Andhra Pradesh is divided into nine zones based on the Agroclimatic conditions (fig 1).Out of the nine Agroclimatic zones of the state, seven Agroclimatic zones were selected for the study. The classification mainly concentrates on the range of Rainfall received, type and topography of the soils.

1. **North Coastal Zone**: This zone covers Srikakulam Vizianagaram, Vishakapatnam and uplands of East Godavari. It receives a rainfall of 1,000 - 1,100 mm during southwest monsoon. The soil type is Red soils with clay base, pockets of acidic soils, laterite soils with PH 4-5. The main crops grown in this zone are rice, groundnut, sorghum, pearl millet, tobacco, cotton, chilly, sugarcane and horticultural crops. The maximum temperature ranges between 29-42 °C while the minimum temperature ranges between 18-27°C.

2. **The Godavari Zone**: It covers East Godavari Part, West Godavari. It receives a rainfall of 800-1100mm. The soil type is deltaic alluvium, red soils with clay, red loams, coastal sands and saline soils. Paddy, Groundnut, Jowar, Bajra, Tobacco, cotton, chilies, Sugarcane and horticultural crops are the main crops grown and the maximum temperature ranges between 29-42°C while the minimum temperature ranges between 16-24°C.

3. **Krishna Zone:** This zone covers **Krishna, Guntur**, parts of Prakasham, Khammam and Nalgonda. The soil type is deltaic alluvium, red soils with clay base, black cotton soils, red loams, coastal sands and saline soils. The crops


NINE AGRO-CLIMATIC ZONES OF UNDIVIDED
ANDHRA PRADESH
77°0'E
78°0'E
79°0'E
80°0'E
81°0'E
82°0'E
83°0'E
84°0'E
22°0'N
21°0'N
20°0'N
19°0'N
18°0'N
17°0'N
16°0'N
15°0'N
14°0'N
13°0'N
12°0'N
11°0'N
N
W
E
S
ADILABAD
NIZAMABAD
KARIMNAGAR
MEDAK
WARANGAL
KHAMMAM
RANGAREDDY
HYDERABAD
NALGONDA
MAHBUBNAGAR
GUNTUR
KRISHNA
WEST GODAVARI
EAST GODAVARI
YANAM
VISHAKAPATNAM
VIZIANAGARAM
SRIKAKULAM
KURNOOL
PRAKASAM
ANANTAPUR
KADAPA
NELLORE
CHITTOOR
Zones
Central Telangana Zone
Godavari Zone
High Altitude Zone
Krishna Zone
North Coastal Zone
Northern Telangana Zone
Scarce Rainfall Zone
Southern Telangana Zone
Southern Zone
Kilometers
0 20 40 80 120 160

FIG - 1

grown are rice, groundnut, sorghum, pearl millet, tobacco, cotton, chilly, sugarcane and horticultural crops.It receives a rainfall of 800-1100mm. The maximum temperature is between 29°C and 42°C and the minimum temperature ranges between 16°C and 24°C.

4. **North Telangana Zone**: It covers Adilabad, Karimnagar, Nizamabad, Medak (northern part), Warangal (except north western part), eastern tips of **Nalgonda** and **Khammam**. The rainfall received is about 900-1500mm. The soil type is Chalkas, Red sandy soils, dubbas, deep red loamy soils and very deep black cotton soils. The important crops are Paddy, Sugarcane, Castor, Jowar, Maize, and Sunflower, turmeric, pulses and Chilis. The maximum temperature ranges between 24-42°C and the minimum temperature is between 11-28°C.

5. **Central Telangana Zone**: This zone consists of **Warangal**, Medak and Khammam. The rainfall received is about 900-1500mm. The soil type is Chalkas, Red sandy soils, dubbas, deep red loamy soils and very deep black cotton soils. The important crops are Rice, Sugarcane, Castor, Jowar, Maize, and Sunflower, turmeric, pulses and chilies. The maximum temperature ranges between 29-42°C and the minimum temperature is between 11-28°C.

6. **Southern Telangana Zone**: This zone consists of Hyderabad, Ranga Reddy, **Mahaboobnagar** (except southern border), **Nalgonda** (except north eastern border), Medak (Southern parts), Warangal (North western part). This zone gets a rainfall between 700-900mm. Soil type is Red earths with loamy, sub soils (chalkas). Paddy, Sunflower, Safflower, grapes, sorghum, millets, pulses and orchard crops are some of the important crops grown. The maximum temperature ranges between 28-42°C and the minimum temperature is between 12-26°C.

7. **Southern zone**: It consists of Nellore, Chittoor, Southern parts of Prakasham and Cuddapah and Eastern parts of **Ananthapur**. The rainfall ranges between 700-1100mm. The soil type is Red loamy soils, shallow to moderately deep. The main crops grown are Paddy, Groundnut, cotton, sugarcane, millets and horticultural crops. The maximum temperature ranges from 28-40°C and the minimum temperature is between 13-27°C.

8. **Scarce rainfall zone**: The districts covered in this zone are **Kurnool**, **Ananthapur**, Prakasam (western parts), Cuddapah (northern part), **Mahaboobnaga**r (southern border). The rainfall received is between 500-750mm. The soil type is Red earths with loamy soils (chalkas), red sandy soils and black cotton soils in pockets. Cotton, Sorghum, millets, groundnut, pulses and paddy are the important crops that are grown in the area. The maximum temperature ranges between 32-40°C and the minimum temperature is between 13-28°C.
9. **High Altitude and Tribal areas**: The districs that fall under this zone areSrikakulam, Vizianagaram, Visakhapatnam, East Godavari and **Khammam**. It receives a rainfall of more than 1400mm. The cops grown in this area are millets, pulses, chilly, turmeric and pepper.The maximum temperature ranges from 17-35°C and the minimum temperature varies from 6-24°C. The soil type is undulating transported soils covered by hill slopes.

Table 1.2Agroclimatic zones of Andhra Pradesh and their characteristics

Sl.	Zone	District	Rainfall	Temperature	Soil-Type	Crops grown
I	North Coastal Zone	Srikakulam, Vizianagaram, Vishakhapatnam and uplands of East Godavari Districts	Southwest monsoon 1,000-1,100 mm	Max.29-42°C Min.18-27°C.	Red soils with clay base, pockets of acidic soils, laterite soils with PH 4-5	Rice, groundnut, sorghum, pearl millet, tobacco, cotton, Chili, sugarcane and horticultural crops
II	The Godavari Zone	East Godavari Part, West Godavari	Southwest monsoon800-1,100mm	Max.29-42°C Min.16-24°C.	deltaic alluvium, red soils with clay, red loams, coastal sands and saline soils	Paddy, Groundnut, Jowar, Bajra, Tobacco, cotton, Chilis, Sugarcane and horticultural crops
III	Krishna Zone	Krishna, Guntur, parts of Prakasham, Khammam and Nalgonda	Southwest monsoon 800-1100mm	Max.29-42°C Min.16-24°C.	deltaic alluvium, red soils with clay base, black cotton soils, red loams, coastal sands and saline soils	Rice, groundnut, sorghum, pearl millet, tobacco, cotton, Chili, sugarcane and horticultural crops
IV	North Telangana Zone	Adilabad, Karimnagar, Nizamabad, Medak (northern part), Warangal (except north western part), eastern tips of Nalgonda and Khammam	Southwest monsoon 900-1,500mm	Max.24-42°C Min.11-28°C.	Chalkas, Red sandy soils, dubbas, deep red loamy soils and very deep black cotton soils	Paddy, Sugarcane, Castor, Jowar, Maize, Sunflower, turmeric, pulses and Chilis
V	Central Telangana Zone	Warangal, Medak and Khammam	Southwest monsoon 900-1,500mm	Max.29-42°C Min.11-28°C.	Chalkas, Red sandy soils, dubbas, deep red loamy soils and very deep black cotton soils	Rice, Sugarcane, Castor, Jowar, Maize, Sunflower, turmeric, pulses and Chilis
VI	Southern Telangana Zone	Hyderabad, Ranga Reddy, Mahaboobnagar (except southern border), Nalgonda (except north eastern border), Medak (Southern parts), Warangal (North western part)	Southwest monsoon 700-900mm	Max.28-42°C Min.12-26°C	Red earths with loamy, sub soils (chalkas)	Paddy, Sunflower, Safflower, grapes, sorghum, millets, pulses and orchard crops
VII	Southern zone	Nellore, Chittoor, Southern parts of Prakasham and Cuddapah and Eastern parts of Ananthapur	Southwest monsoon 700-1,100mm	Max.28-40°C Min.13-27°C.	Red loamy soils, shallow to moderately deep	Paddy, Groundnut, cotton, sugarcane, millets and horticultural crops
VIII	Scarce rainfall zone	Kurnool, Ananthapur, Prakasam (western parts), Cuddapah (northern part), Mahaboobnagar (southern border)	Southwest monsoon 500-750mm	Max.32-40°C Min.13-28°C	Red earths with loamy soils (chalkas), red sandy soils and black cotton soils in pockets	Cotton, Sorghum, millets, groundnut, pulses and paddy
IX	High Altitude and Tribal areas	Srikakulam, Vizianagaram, Visakhapatnam, East Godavari and Khammam	Southwest monsoon >1,400mm	Max.17-35°C Min.6-24°C	Undulating transported soils covered by hill slopes	Millets, pulses, chilly, turmeric and pepper

DATABASE AND METHODOLOGY:

This study is planned for understanding the spatial patterns and was analyzed the variability of the impact of climate change on agriculture within the state of Andhra Pradesh. Out of the nine agroclimatic zones of the state, seven agroclimatic zones have been selected.From these seven selected agroclimatic zones eight districts were taken for the study (Fig-2) and four to five mandals from each zone have been identified totaling them to thirty-eight mandals (Table No. 1.3). These mandals were selected based on co-variance of rainfall data (Fig-2A-H).

To understand the changes in the rainfall patterns and its impact on crop productivity meteorological socio-economic and agricultural data were used.The agricultural data was collected from the Directorate of Economic and Statistics of the Government of Andhra Pradesh and Mandal Revenue Office for a period of 1988 – 2012 and was analyzed at the mandal and district level.District Hand books and Gazetteers of all the district were referred for preliminary information of the region (state).Data from the satellite imageries for the selected mandals were taken from APSRAC.The climate / meteorological data were procured from the Indian Meteorological department – IMD.

The primary data included the field study of the selected mandals and ground data verification related to land use / land cover.Using SPSS-20 and micro soft excel a statistical analysis of rainfall, temperature and yield pattern were undertaken to comprehend the relationship between different parameters.From the climatic point of view twenty-five years data pertaining to maximum and minimum average temperature, rainfall have been analyzed to gauge the variation trend for all the selected mandals.Major crops namely Paddy, Maize, Jowar, Chilis and Groundnut, on the basis of their area under production have been identified in the selected mandals and their yield variations have been studied. Using statistical techniques like Pearson Correlation, Multiple Regression analytical procedures were used to understand the parametric relations, the spatial and temporal trends in crop productivity and rainfall variability has been worked out.

Using equation (1) described below the multiple linear regression analysis was done to ascertain the impact of rainfall, temperature human labor hour and fertilizer input on crop yields.

$Y = f (F, HL, AR, Max. Temp, Min. Temp)$

Y = Yield in kg per Hectare
F = Fertilizers in kg per Hectare
HL = Human labor hour per Hectare
AR = Actual Rainfall (mm)
Max. Temp = Maximum Temperature in ^0C
Min. Temp = Minimum Temperature in ^0C

SELECTED DISTRICTS OF ANDHRA PRADESH

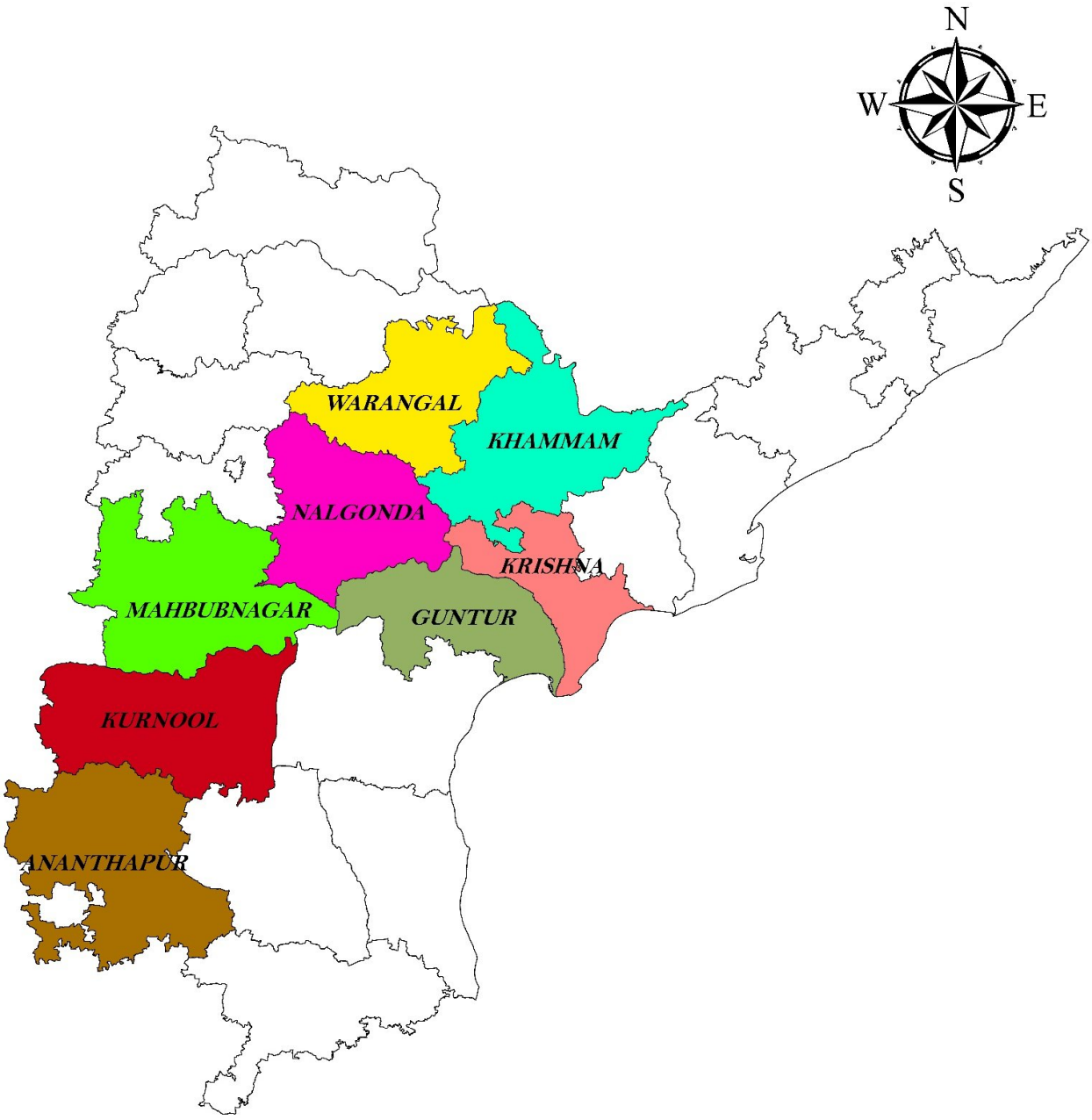


FIG - 2

Combinations of various parameters listed above were analyzed to understand how they were dependent on one another and how they affected agricultural productivity to assess the impact of rainfall in GDP.

Along with the climatic parameters human labor and fertilizer input have also been taken into consideration as they seem to have a major impact on GDP.In order to assess the impact of the monsoon on the GDP for specific year, it is required to estimate what the GDP would have been in the absence of the fluctuations of the monsoon i.e., long term trends.It is expected that the rate of the GDP at any point of time is proportional to the value of the GDP at that point of time.Agriculture is sensitive to both short and long-term changes in weather, which in turn affect crop productivity and thereby the Gross Domestic Product of the region.For this land use patterns, climatic factors, agricultural productivity and GDP for the period 1988 – 2012 were used.Statistical methods including multiple regression analysis and ordinary least square (OLS) methods were used.

METHODOLOGY

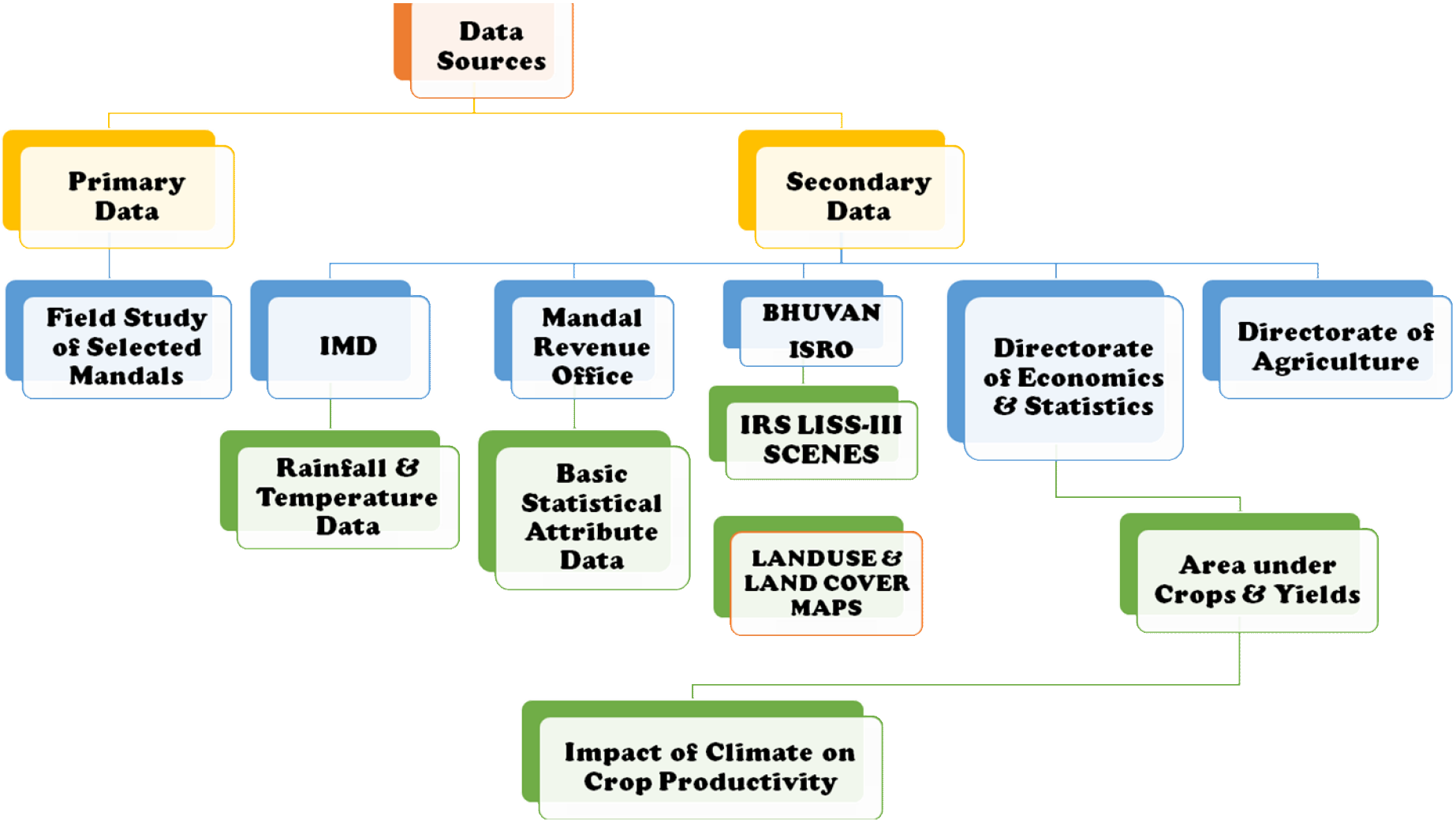


TABLE – 1.3
SELECTED DISTRICTS AND MANDALS OF ANDHRA PRADESH WITH THEIR AGROCLIMATIC ZONES

DISTRICTS	MANDALS	AGROCLIMATIC ZONES
KHAMMAM	BONAKAL	HIGH ALTITUDE AND TRIBAL AREAS ZONE, CENTRAL TELANGANA ZONE (THESES MANDALS BELONG TO CENTRAL TELANGANA ZONE)
	CHINTAKANI	
	MADHIRA	
	MUDIGONDA	
	NELAKONDAPALLE	
	WYRA	
MAHABUBNAGAR	ALAMPUR	SOUTHERN TELANGANA ZONE, SCARCE RAINFALL ZONE (THESE MANDALS BELONGS TO SCARCE RAINFALL ZONE)
	ITKYAL	
	MANOPADU	
	PEBBAIR	
	WADDEPALLI	
NALGONDA	KODAD	SOUTHERN TELANGANA ZONE, NORTHERN TELANGANA ZONE (THESE MANDALS BELONGS TO NORTHERN TELANGANA ZONE)
	MOTHEY	
	MUNGALA	
	NADIGUDAM	
WARANGAL	JANGAON	CENTRAL TELANGANA ZONE
	MARIPEDA	
	MULUGU2	
	RAGHUNATHPALLE	
GUNTUR	BHATTIPROLU	KRISHNA ZONE
	CHERUKUPALLE	
	KOLLUR	
	NAGARAM	
	REPALLE	
	VEMUR	
KRISHNA	CHALLAPALLE	KRISHNA ZONE
	GHANTASALA	
	GUDURU	
	MACHILIPATNAM	
	MOVVA	
ANANTHAPUR	NARPALA	SCARCE RAINFALL ZONE
	PUTLUR	
	TALUPULA	
	YADIKI	
KURNOOL	ADONI	SCARCE RAINFALL ZONE
	KALLUR2	
	MAHANANDI	
	VELDURTHY	

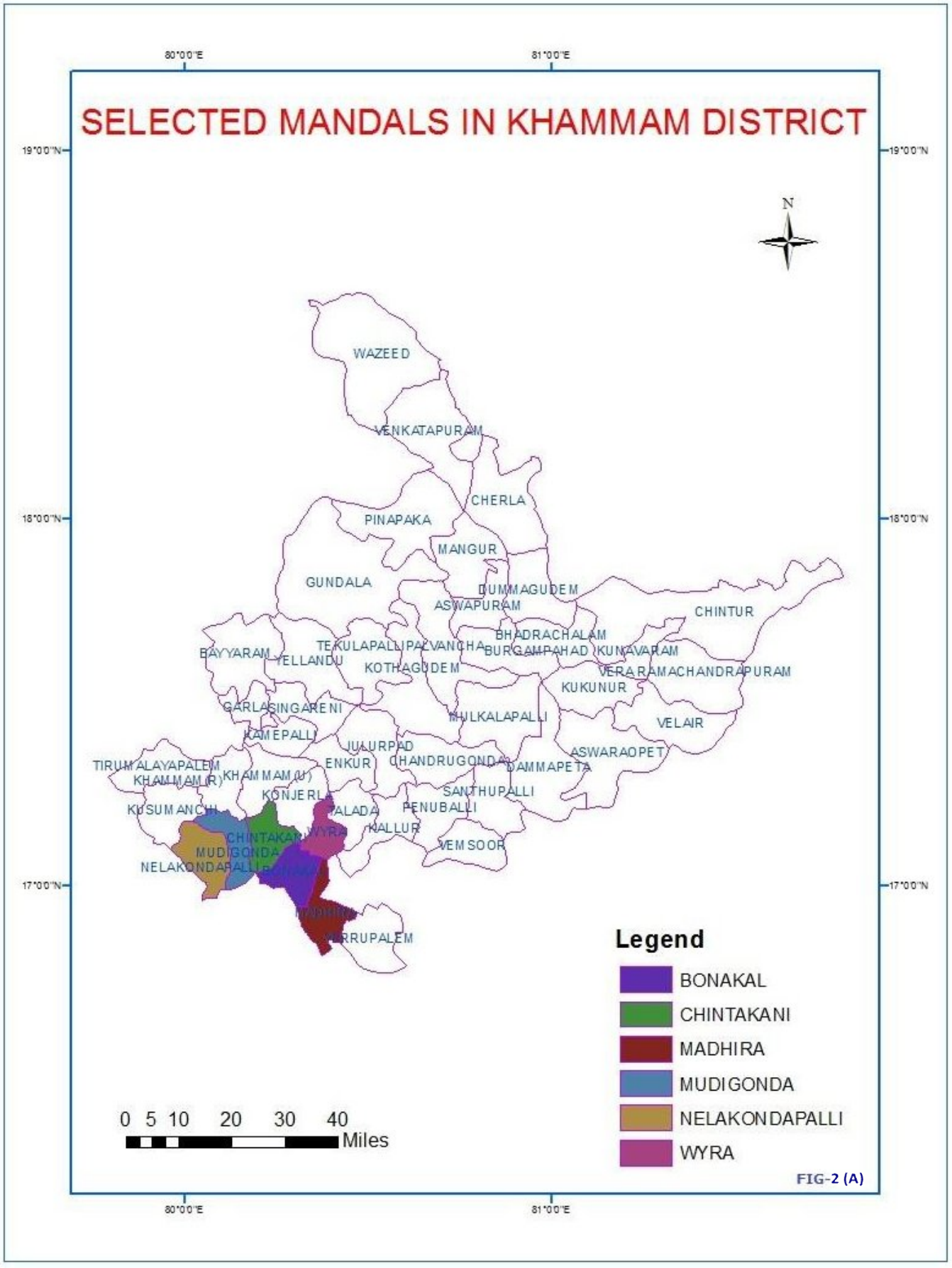

SELECTED MANDALS IN KHAMMAM DISTRICT
80°0'0"E
81°0'0"E
19°0'0"N
18°0'0"N
17°0'0"N
N
WAZEED
VENKATAPURAM
CHERLA
PINAPAKA
MANGUR
GUNDALA
DUMMAGUDEM
ASWAPURAM
CHINTUR
BHADRACHALAM
BURGAMPAHAD
KUNAVARAM
PAYYARAM
YELLANDU
TEKULAPALLI
PALVANCHA
KOTHAGUDEM
VEERAMACHANDRAPURAM
KUKUNUR
GARLASINGARENI
MULKALAPALLI
VELAIR
KAMEPALLI
JULURPAD
ASWARAOPET
TIRUMALAYAPALEM
ENKUR
CHANDRUGONDA
DAMMAPETA
KHAMMAM(R)
KHAMMAM(U)
KONJERLA
SANTHUPALLI
KUSUMANCHI
PENUBALLI
KALLUR
CHINTAKANI
WYRA
MUDIGONDA
VEMSOOR
NELAKONDAPALLI
MADHIRA
BONAKAL
0 5 10 20 30 40
Miles
Legend
BONAKAL
CHINTAKANI
MADHIRA
MUDIGONDA
NELAKONDAPALLI
WYRA

FIG-2 (A)

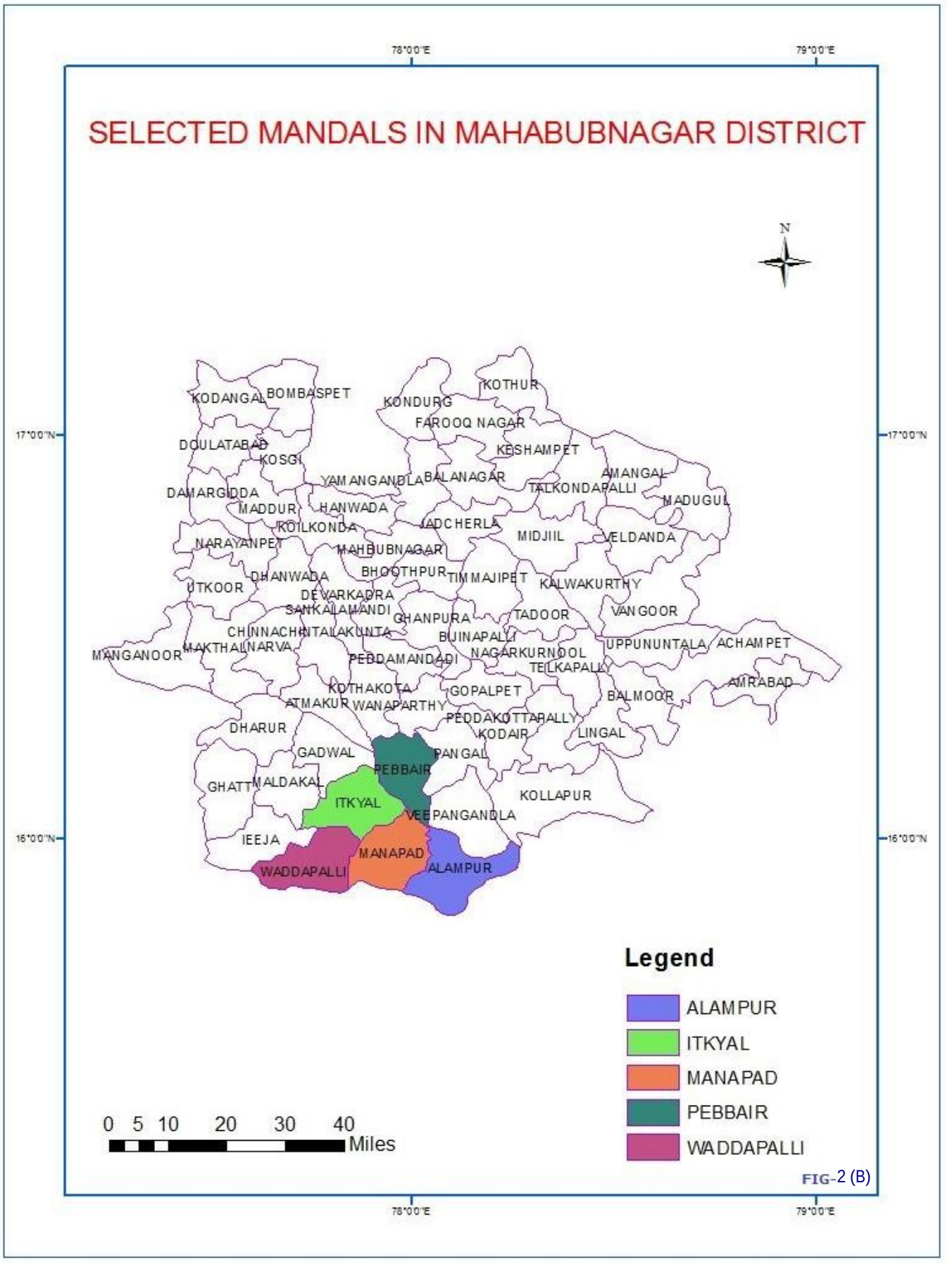

SELECTED MANDALS IN MAHABUBNAGAR DISTRICT
78°0'0"E
79°0'0"E
17°0'0"N
16°0'0"N
N
KODANGAL
BOMBASPET
KONDURG
KOTHUR
FAROOQ NAGAR
KESHAMPET
DOULATABAD
KOSGI
YAMANGANDLA
BALANAGAR
AMANGAL
TALKONDAPALLI
MADUGUL
DAMARGIDDA
MADDUR
HANWADA
KOILKONDA
JADCHERLA
MIDJIIL
VELDANDA
NARAYANPET
MAHBUBNAGAR
DHANWADA
BHOOTHPUR
TIMMAJIPET
KALWAKURTHY
UTKOOR
DEVARKADRA
SANKALAMANDI
GHANPURA
TADOOR
VANGOOR
CHINNACHINTALAKUNTA
BIJINAPALLI
UPPUNUNTALA
ACHAMPET
MANGANOOR
MAKTHALNARVA
PEDDAMANDADI
NAGARKURNOOL
TELKAPALLY
AMRABAD
KOTHAKOTA
GOPALPET
BALMOOR
ATMAKUR
WANAPARTHY
PEDDAKOTTARALLY
DHARUR
KODAIR
LINGAL
GADWAL
PANGAL
PEBBAIR
GHATT
MALDAKAL
ITKYAL
KOLLAPUR
VEEPANGANDLA
IEEJA
MANAPAD
WADDAPALLI
ALAMPUR
Legend
ALAMPUR
ITKYAL
MANAPAD
PEBBAIR
WADDAPALLI
0 5 10 20 30 40
Miles

FIG-2 (B)

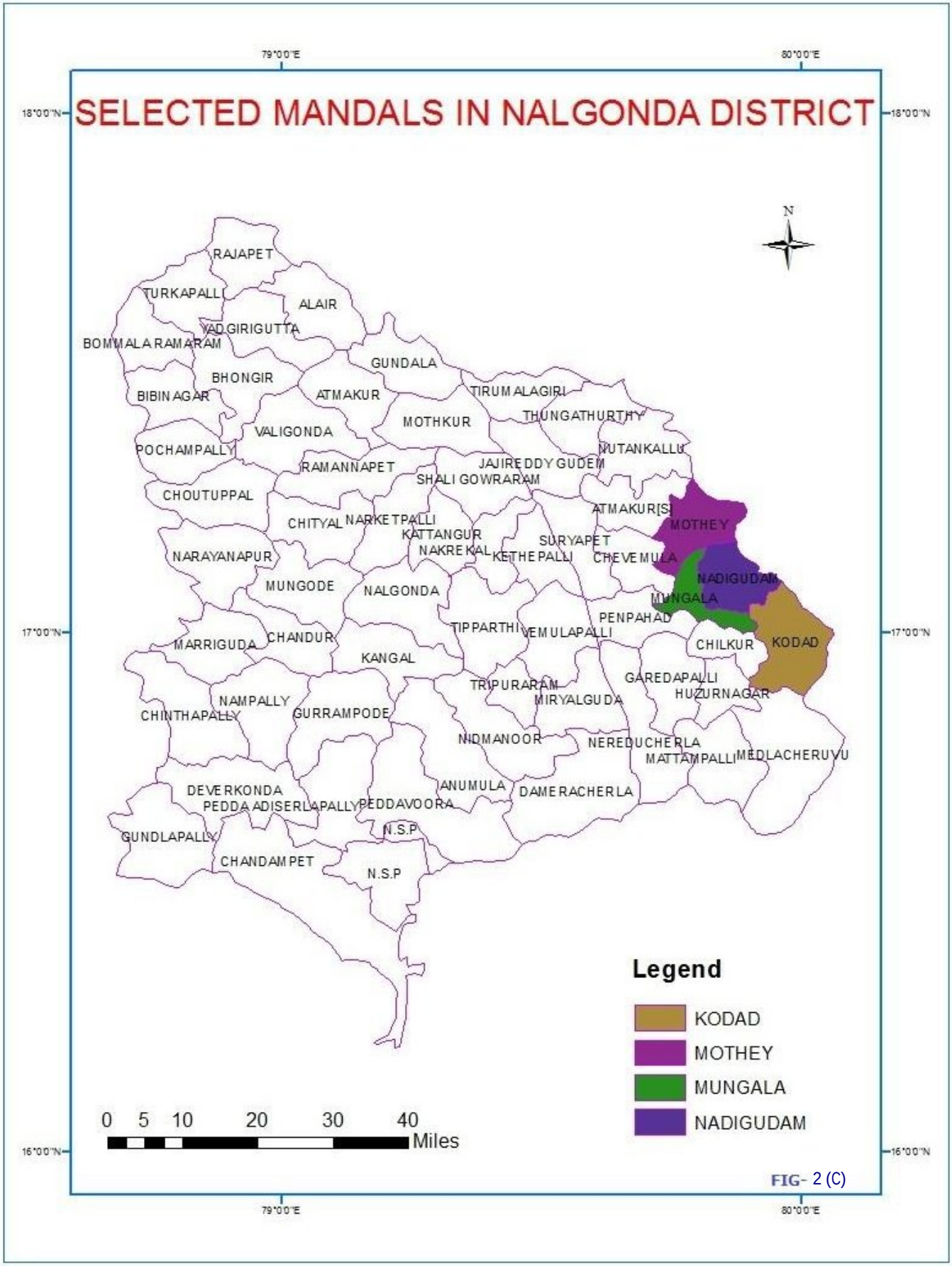

SELECTED MANDALS IN NALGONDA DISTRICT
79°0'0"E
80°0'0"E
18°0'0"N
17°0'0"N
16°0'0"N
N
RAJAPET
TURKAPALLI
ALAIR
YADGIRIGUTTA
BOMMALA RAMARAM
GUNDALA
BHONGIR
BIBINAGAR
ATMAKUR
TIRUMALAGIRI
THUNGATHURTHY
MOTHKUR
VALIGONDA
POCHAMPALLY
MUTANKALLU
RAMANNAPET
JAJIREDDY GUDEM
SHALI GOWRARAM
CHOUTUPPAL
ATMAKUR[S]
MOTHEY
CHITYAL
NARKETPALLI
KATTANGUR
NAKREKAL
SURYAPET
KETHEPALLI
CHEVEMULA
NARAYANAPUR
NADIGUDAM
MUNGODE
NALGONDA
MUNGALA
PENPAHAD
TIPPARTHI
VEMULAPALLI
CHILKUR
KODAD
MARRIGUDA
CHANDUR
KANGAL
GAREDAPALLI
TRIPURARAM
HUZURNAGAR
MIRYALGUDA
NAMPALLY
CHINTHAPALLY
GURRAMPODE
NIDMANOOR
NEREDUCHERLA
MATTAMPALLI
MEDLACHERUVU
DEVERKONDA
ANUMULA
DAMERACHERLA
PEDDA ADISERLAPALLY
PEDDAVOORA
N.S.P
GUNDLAPALLY
CHANDAMPET
N.S.P
Legend
KODAD
MOTHEY
MUNGALA
NADIGUDAM
0 5 10 20 30 40
Miles

FIG- 2 (C)

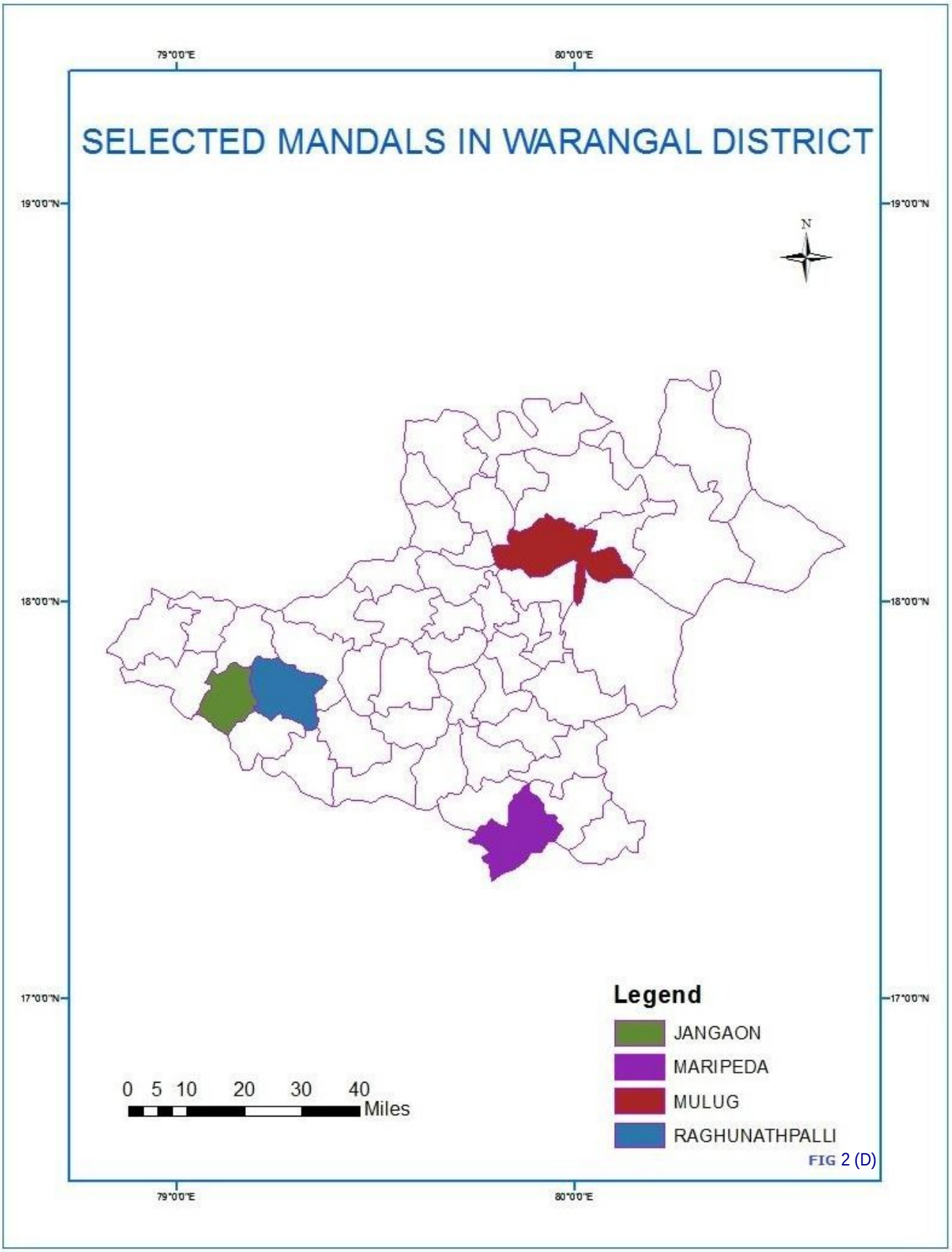

SELECTED MANDALS IN WARANGAL DISTRICT
79°0'0"E
80°0'0"E
19°0'0"N
18°0'0"N
17°0'0"N
N
0 5 10 20 30 40
Miles
Legend
JANGAON
MARIPEDA
MULUG
RAGHUNATHPALLI

FIG 2 (D)

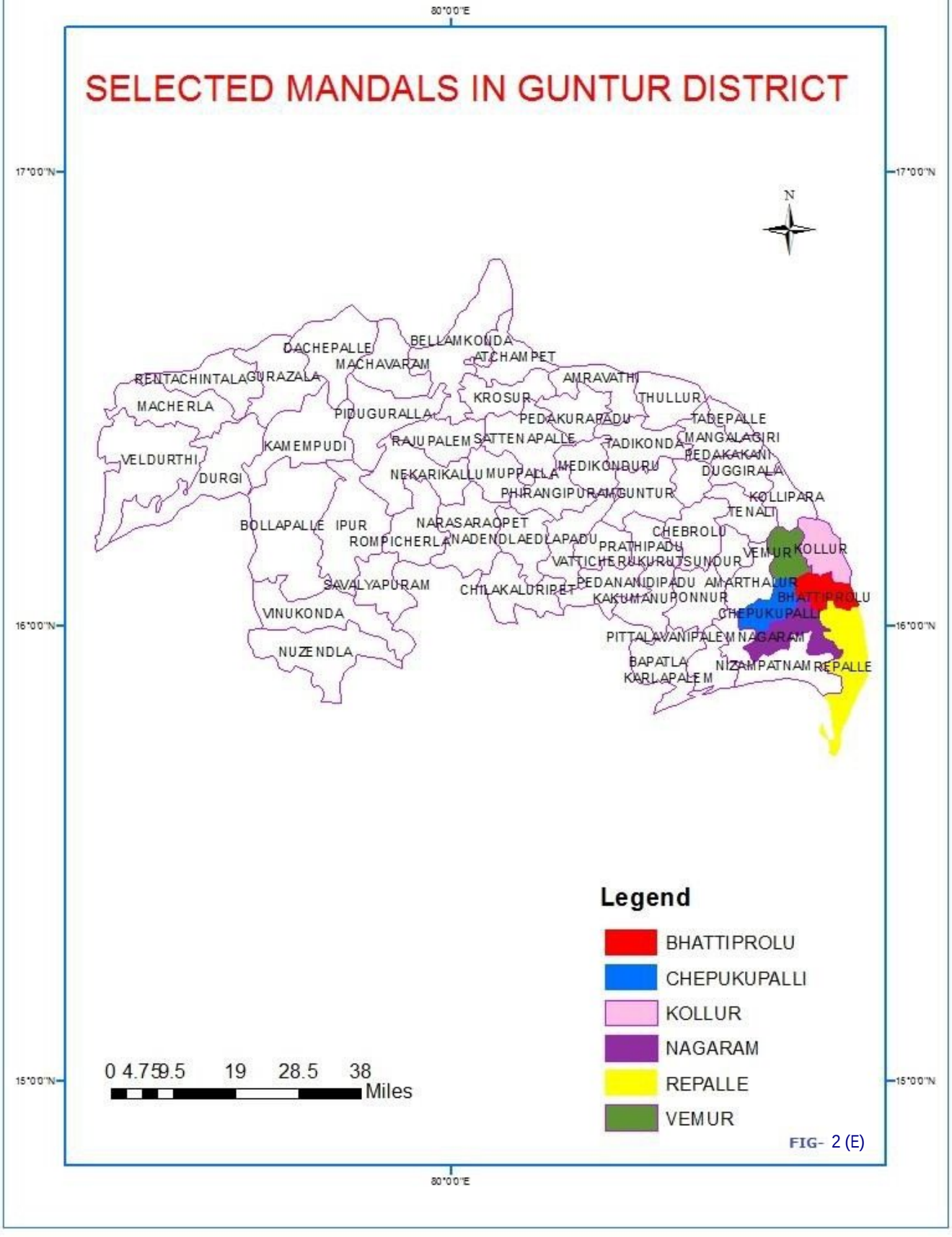

SELECTED MANDALS IN GUNTUR DISTRICT
80°0'0"E
17°0'0"N
16°0'0"N
15°0'0"N
N
DACHEPALLE
BELLAMKONDA
MACHAVARAM
ATCHAMPET
REntachintala
GURAZALA
AMRAVATHI
MACHERLA
KROSUR
THULLUR
PIDUGURALLA
PEDAKURAPADU
TADEPALLE
KAMEMPUDI
RAJUPALEM
SATTENAPALLE
TADIKONDA
MANGALAGIRI
VELDURTHI
PEDAKAKANI
MEDIKONDURU
DUGGIRALA
DURGI
NEKARIKALLU
MUPPALLA
PHIRANGIPURAM
GUNTUR
KOLLIPARA
TENALI
BOLLAPALLE
IPUR
NARASARAOPET
CHEBROLU
ROMPICHERLA
NADENDLA
EDLAPADU
PRATHIPADU
VEMUR
KOLLUR
VATTICHERUKURU
TSUNDUR
PEDANANDIPADU
AMARTHALUR
SAVALYAPURAM
CHILAKALURIPET
KAKUMANU
PONNUR
BHATTIPROLU
CHEPUKUPALLI
VINUKONDA
PITTALAVANIPALEM
NAGARAM
NUZENDLA
BAPATLA
NIZAMPATNAM
REPALLE
KARLAPALEM
0 4.75 9.5 19 28.5 38
Miles
Legend
BHATTIPROLU
CHEPUKUPALLI
KOLLUR
NAGARAM
REPALLE
VEMUR

FIG- 2 (E)

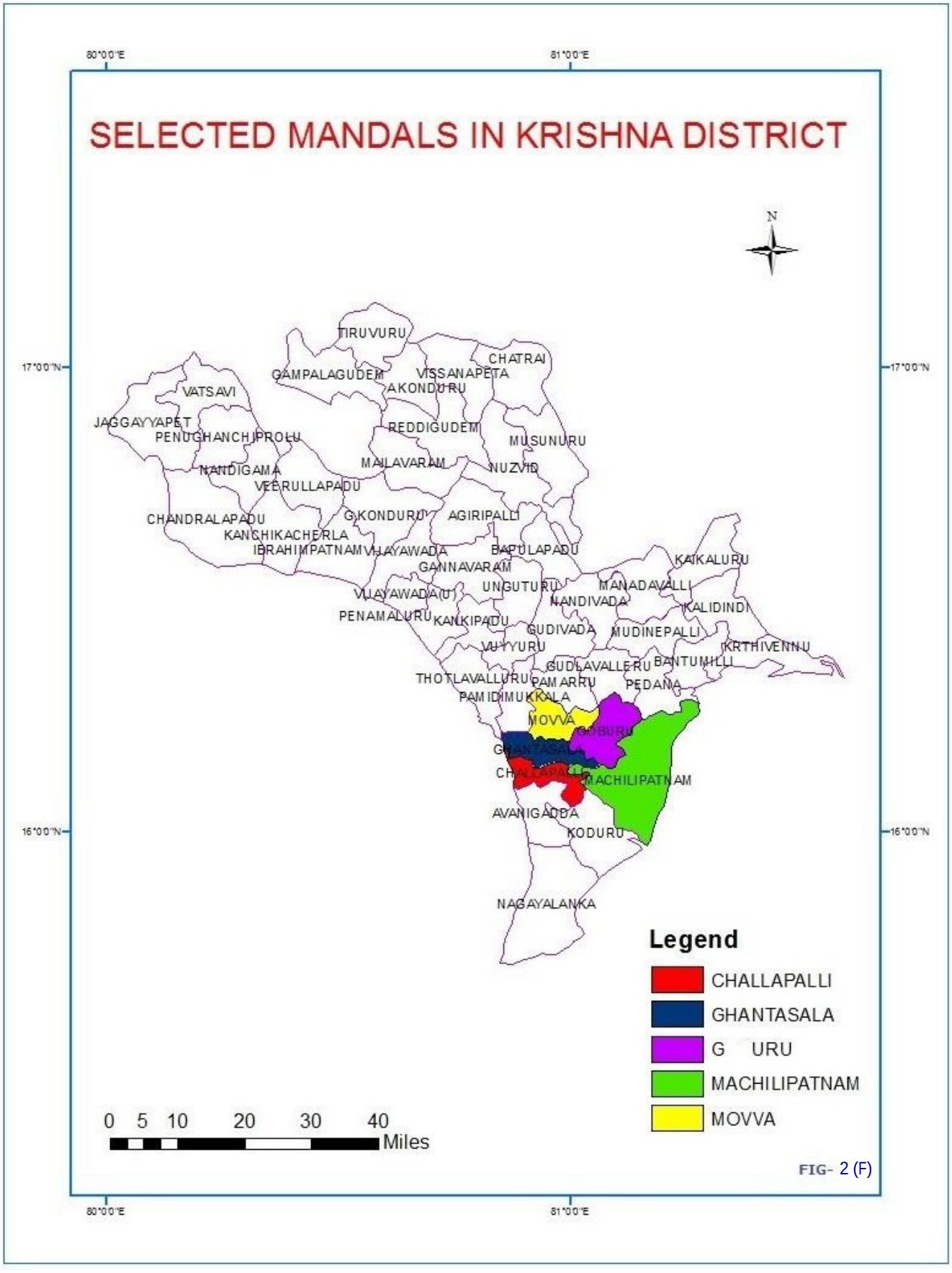

SELECTED MANDALS IN KRISHNA DISTRICT
80°0'0"E
81°0'0"E
17°0'0"N
16°0'0"N
N
TIRUVURU
CHATRAI
GAMPALAGUDEM
VISSANAPETA
AKONDURU
VATSAVI
JAGGAYYAPET
PENUGHANCHIPROLU
REDDIGUDEM
MUSUNURU
NANDIGAMA
MAILAVARAM
NUZVID
VEERULLAPADU
CHANDRALAPADU
G.KONDURU
AGIRIPALLI
KANCHIKACHERLA
IBRAHIMPATNAM
VIJAYAWADA
BAPULAPADU
KAIKALURU
GANNAVARAM
UNGUTURU
MANADAVALLI
VIJAYAWADA(U)
NANDIVADA
KALIDINDI
PENAMALURU
KANKIPADU
GUDIVADA
MUDINEPALLI
VUYYURU
KRTHIVENNU
GUDLAVALLERU
BANTUMILLI
THOTLAVALLURU
PAMARRU
PEDANA
PAMIDIMUKKALA
MOVVA
GHANTASALA
CHALLAPALLI
MACHILIPATNAM
AVANIGADDA
KODURU
NAGAYALANKA
Legend
CHALLAPALLI
GHANTASALA
G URU
MACHILIPATNAM
MOVVA
0 5 10 20 30 40
Miles

FIG- 2 (F)

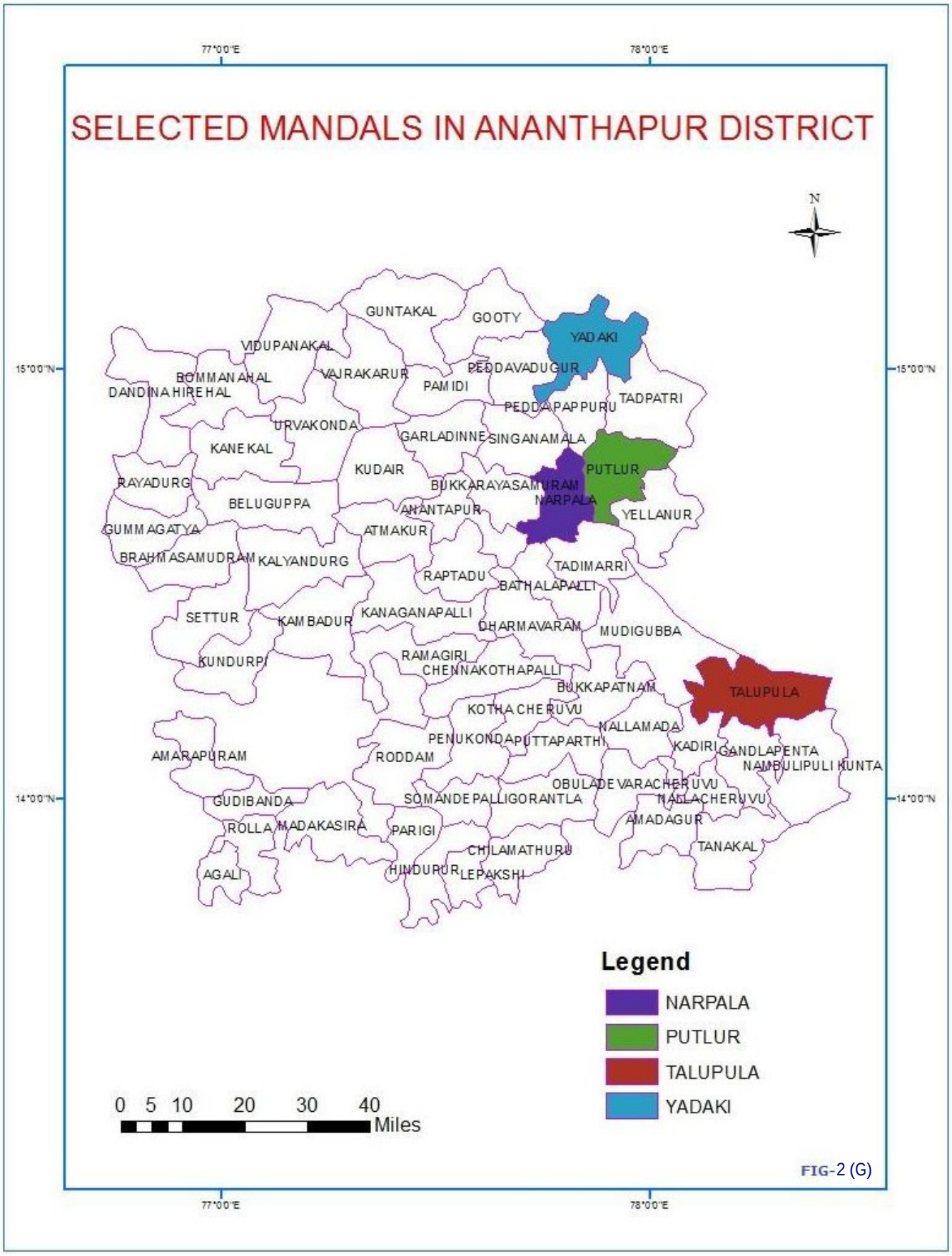

SELECTED MANDALS IN ANANTHAPUR DISTRICT
77°00'E
78°00'E
15°00'N
14°00'N
N
GUNTAKAL
GOOTY
YADAKI
VIDUPANAKAL
PEDDAVADUGUR
BOMMANAHAL
VAJRAKARUR
PAMIDI
DANDINAHIREHAL
TADPATRI
PEDDAPAPPURU
URVAKONDA
GARLADINNE
SINGANAMALA
KANEKAL
PUTLUR
KUDAIR
RAYADURG
BUKKARAYASAMUDRAM
NARPALA
BELUGUPPA
ANANTAPUR
YELLANUR
GUMMAGATYA
ATMAKUR
BRAHMASAMUDRAM
KALYANDURG
TADIMARRI
RAPTADU
BATHALAPALLI
SETTUR
KANAGANAPALLI
KAMBADUR
DHARMAVARAM
MUDIGUBBA
RAMAGIRI
KUNDURPI
CHENNAKOTHAPALLI
BUKKAPATNAM
TALUPULA
KOTHACHERUVU
NALLAMADA
PENUKONDA
PUTTAPARTHI
KADIRI
GANDLAPENTA
AMARAPURAM
RODDAM
NAMBULIPULIKUNTA
OBULADEVARACHERUVU
GUDIBANDA
SOMANDEPALLI
GORANTLA
NALLACHERUVU
ROLLA
MADAKASIRA
PARIGI
AMADAGUR
CHILAMATHURU
TANAKAL
AGALI
HINDUPUR
LEPAKSHI
Legend
NARPALA
PUTLUR
TALUPULA
YADAKI
0 5 10 20 30 40
Miles

FIG-2 (G)

SELECTED MANDALS IN KURNOOL DISTRICT

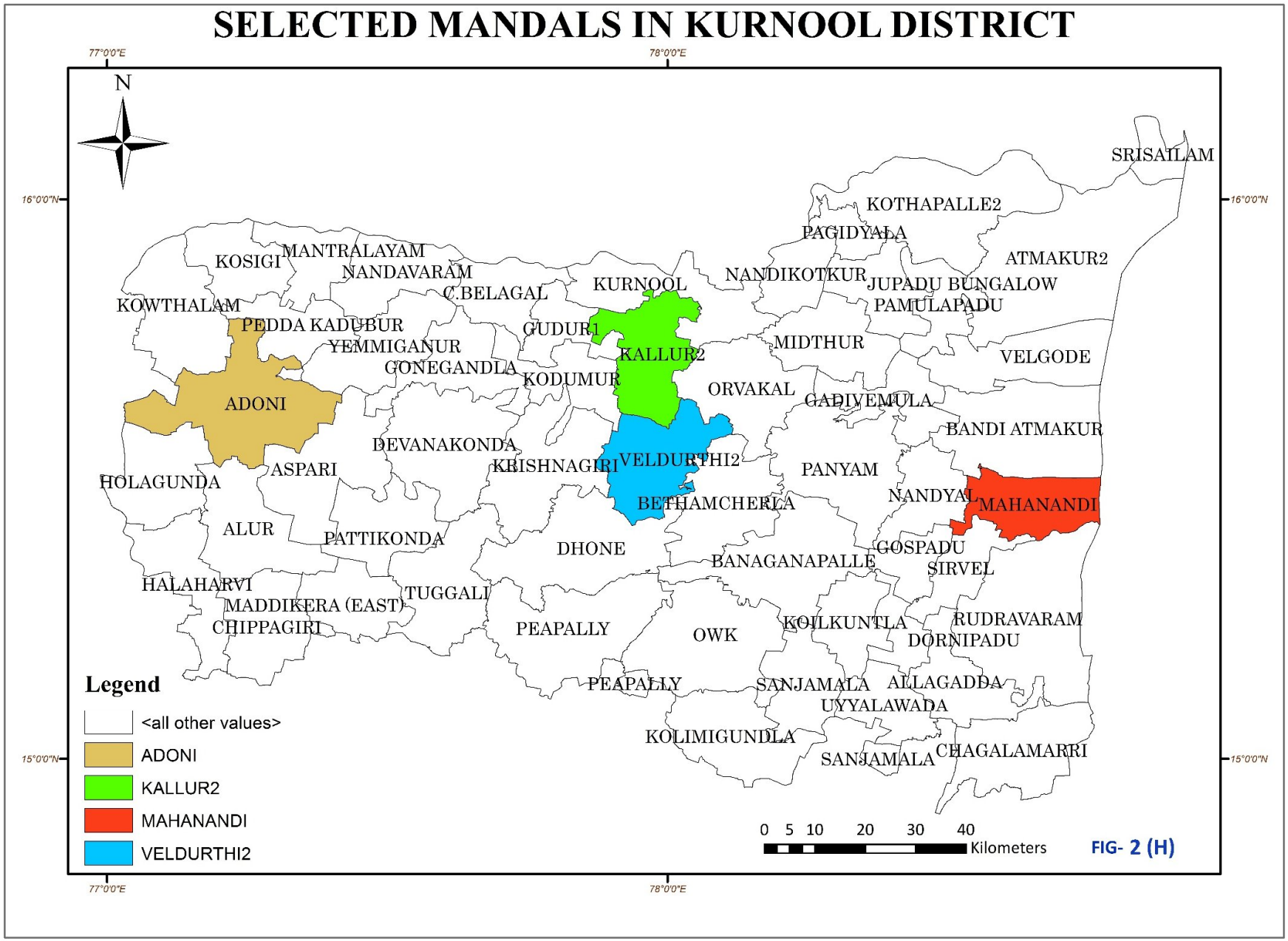


FIG- 2 (H)

CHAPTER-II
LANDUSE/LAND COVER ANALYSIS OF THE STUDY AREA

LAND USE/LAND COVER ANALYSIS OF THE STUDY AREA

Knowledge of land use/land cover is important for many planning and management activities concerned with the surface of earth. Land use describes how a parcel of land is used whereas land cover describes the materials present on the surface. The land cover of an area may be forest, vegetation, rocks, waterbodies etc., but land use may be of various combinations of activities such as agriculture, settlements, networks etc. Accurate current information of land use/land cover is essential for many planning activities.

Remote Sensing and GIS technology are becoming increasingly important for mapping land use/land cover for several reasons. Images of large areas can be acquired rapidly with a high spatio-temporal resolution that meets the degree of detail required for the study. Using GIS technology, the analysis and interpretation of remotely sensed images have become faster and less expensive than conducting ground surveys. And also, it allows the interpreter to detect the change of land use and land cover over a period of years, so that the problem could be found and suggested a better solution to that. This helps the spatial thinkers and planners to take a better decision for the further spatial and socio-economic development of the lands.

Information Technology has played another important role in planning and land management. Several computer aided systems such as Land Information and Management Systems, Forest Inventory Systems and Resource Information and Management Systems etc. provide a wide variety of accurate and temporal information about the land resources and the existing features on it. This has become useful for linking the parcel maps of the lands to the secondary data for statistical analysis.

These technologies altogether are vital for studying the Land Utilization, Agroclimatic and Agro-Ecological Zoning of large geographic regions, various human activities, growing agricultural and economic demand of the growing population and positive and negative impact of the climate change and human interference in planning prospect etc. A Comprehensive, Accurate and Updated information collected using these technologies are adopted by the spatial planners as it helps studying the drawback in land utilization, the laxity of Plan Implementation, Improperness of Planning, Shortage, Improper Use or Unavailability of Resources, Common Human Practice for Livelihood, Demand and Supply Chain etc. in the past and present time, and predicting the future, according to which the land can be utilized to the best of its Class, Type and Capacity.

In this context it is imperative to have knowledge of existing land utilization pattern of the study area (Selected mandals), which are as follows.

KHAMMAM DISTRICT

BONAKAL:

Bonakal mandal occupies an area of 15843.47 hectares of land within Khammam District (Table No. 2.1). 760.57 hectares (4.8%) of the total land is covered by waterbodies out of which only 17 hectares are used for aquaculture. Longitudinally along the eastern border of the mandal, a small perennial stream is seen and other non-perennial streams or canals also pass through the western-central part which is oriented north-south. Watersheds are seen dispersed throughout the mandal. These watersheds and running waterbodies are best used for irrigation of the crop fields. That's why almost 14315.95 hectares of land (90.36%) is used for agricultural purpose excluding the land used for aquaculture. Because of very good availability of ground seasonal and permanent ground water, 76.27% of the total agricultural land that is 68% of the mandal is cropped in two seasons. But it is seen in that some places of the central and south-western regions, kharif crops are cultivated, in nearly 2079.81 hectares of land (13.13% of the mandal area). The reason may be that the quality of soil is hard and dry or maybe they are high lands where irrigation is not possible. But cultivation of rabi crops is quite less in the mandal to that extent and is found in the extreme north and south-eastern border regions Fallow land is seen in small patches throughout the mandal. These cover a sum total of 2.34% of land (371.51 hectares), mostly within the southern part. Land used for agricultural plantation is also very less in the mandal. These are only 554.82 hectares or 3.5% of land parcels dispersed within the west-central, south-western and some places of the southern regions of the mandal fig-3 Only 313.65 hectares of lands are found to be unused or wastelands, seen near the rural settlement areas within the central region. Like all other agricultural areas, here also, only rural settlements have grown individually throughout the mandal. This occupies only 2.86% (453.30 hectares) of the total area of the mandal. Forest cover is nowhere seen within the entire mandal. For the best utilization of land, the wastelands covered by scrubs could be used for poultry farming, animal husbandry, and constructing crop storehouses etc. The fallow lands could be turned into vegetation cover by planting commercial plants *like. Bamboo, Teak or Sal trees*. If lands could be used for plantation, then there is a possibility of establishing wood industries in future which can attract the workers towards the employment sector. Lift irrigation and bore well irrigation within the kharif cropped lands can make the lands more productive to cultivate rabi crops.

CHINTHAKANI:

Chinthakani mandal occupies an area of 18753.43 hectares within Khammam District (Table No. 2.2). Out of this 16891.91 hectares of lands are used for agriculture. These comprise more than 90% of the total land use. 896.19 hectares

(4.78%) of land is covered by water bodies (Fig-3). Perennial and non-perennial streams flow along the western border of the mandal and a canal also passes longitudinally through the eastern region. More number of seasonal and less number of permanent ground water catchments are seen everywhere. It seems the crop lands get moisturized because of these ground watersheds. Since these watersheds are seasonal and permanent, the water supply is available in both the seasons. Hence it is seen that most of the agricultural lands (13830.61ha or 73.75% of the total land) are cultivated in two seasons and few places from the north central and western belt from north to south, are found to be rain dependent. That is the reason why kharif crops are cultivated in 2128.31 ha (11.35% of the total mandal area) of land within the mandal. The possibility of these places being dependent on rain may be because of the land elevation and the resultant lack of irrigation. But digging artificial watersheds like well Irrigation, pond irrigation can facilitate the cultivation of rabi crops, as only 2.62% of the total land is rabi cropped. Unlike other mandals of the district, fallow lands are very less here, (nearly1.52% or 285.14 ha). And the wastelands occupy as 343.79 ha or 1.83% of the total land. So, 3.66% of the total area of the mandal has turned it to be unproductive. For an improved land use, these places can be used for agro based industrial set ups and establishing stone reprocessing units because quarries are also seen in some of the places in the extreme north and south regions. Only 3.01% of the total mandal area is used for rural settlements which are found scattered within the mandal. Forest cover is completely absent in the mandal.

MADHIRA:

Madhira is spread over an area of 20551.15 ha of land within Khammam District (Table No. 2.3). 5.26% of the total land (1081.92 ha) is covered by waterbodies. A major stream passes through the mandal from north to south separating the south-western part from the mandal. This is a great source of water supply to the crop lands and is perennial. Non-perennial streams or rivers are hardly seen near the southern border of the mandal. Seasonal and a few permanent ground watersheds are located in the central region of the mandal. A small canal is present at the extreme eastern part. Although more than 5% of the total land is covered by waterbodies, because of the seasonal availability of water instead of permanent availability and poor facility of irrigation within the mandal 45.78% (9407.3 ha) of the total area of the mandal is dependent on rain fed water, and the land is used for kharif crop. This is a major drawback in land use. Only 31.39% of land (6452 ha) is cropped in two seasons. And these places are mostly found along the seasonal/permanent ground watersheds and perennial or non-perennial streams. And because of this only 3.05% of land is rabi cultivated and their crops are grown near these canals and non-perennial streams. Because of inadequate water supply facility, 5.77% (1185.76 ha) of the total land is used for plantation and 3.41% (701.69 ha) of the total land is fallow. 18373.12 Ha (89.40%) of land are used as agricultural lands. But out of that 9.18% has become unproductive as these are fallow or used commercially. There may be several causes for this type of land use in the mandal (fig-3). Industrial land use has been observed in the central part of the mandal. So there may be the chance of people

getting engaged in industrial sector rather than agriculture. The total built up area consists of 676.34 ha or 3.29% of the total land available. In this case, a well-planned irrigation model is required to improve the agricultural standard and the productivity of the lands. Again 1.88% of land is found to be wastelands and seen scattered in small patches throughout the mandal area. These places can be used for animal husbandry, and the agricultural plantation areas can also be used for animal husbandry. So, the land becomes more fertile after being used for multipurpose over a period of time. It can be expected to be used for mixed crop cultivation or zaid crop cultivation in future. This is possible because more than 5% of the total land is marked as water catchment areas. But these are not properly used for irrigation. Forest cover is completely absent here. No quarries or mining activities are seen. So, people of the mandal mainly depend either on seasonal kharif crop or industrial employment sector.

MUDIGONDA:

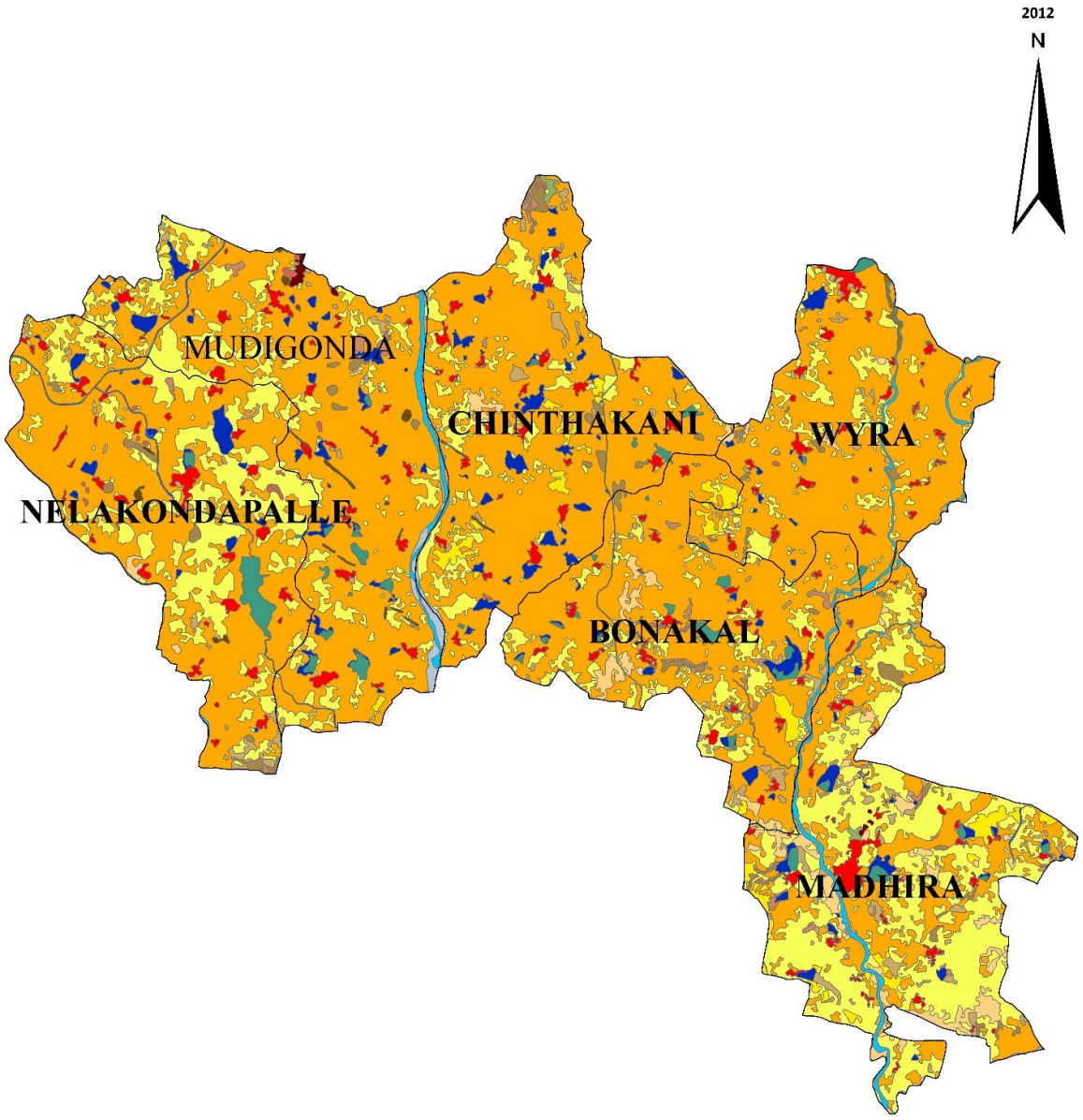
Mudigonda mandal has occupied an area of 20537.10 ha of land in the Khammam district (Table No. 2.4). Out of the total area 7.81% of land is covered by water bodies (fig-3). A wide mix of perennial and non-perennial streams flow along the eastern border from north to south. Which has become the major source of irrigation for the croplands. Other two canals cross diagonally in the north and south regions. These also play a major role in irrigating the areas. Another rich source of surface waterbodies are the seasonal and permanent water catchment areas found throughout the mandal. These allow the croplands to be thoroughly irrigated and make the lands more productive and can be cropped in two seasons. As the land seems to be adequately irrigated, rabi cropped areas are found very less in number. But may be because of the less water containing capacity and highlands, some of the places in the northern part and alongside the western border are seen to be kharif cropped areas. These areas occupy 3374.12 ha (16.43%) of the total land. Hence 14252.86 ha (64.4%) of the total land is cropped in two seasons. Only 204.14 ha or 0.99% of land is follows. This way, almost 17857.97 ha (86.95%) of land is used as agricultural land. But some places are found to be used for development industrial in the north-eastern part of the mandal. Rural settlement areas can be seen everywhere within the agro fields. 3.5% of the total land is used for. But 1.74% of land (357.7 ha) has been found to be wasteland. No forest cover is present within the mandal. Even the areas surrounding the perennial streams can be used for pisciculture or seasonal aqua culture.

NELAKONDAPALLE:

Nelakondapalle mandal of Khammam district is extended over 19043.05 ha of land (Table No. 2.5). 981.82 Ha (4.4%) of the total mandal area is concealed by waterbodies. Amongst these waterbodies, a perennial stream passes along the entire western border of the mandal and two canals divide the mandal into three parts. These play the most important role in irrigation and water supply to the agricultural lands.

These canals are sourced from a permanent surface watershed located centrally in the mandal. And also, the presence of other large and small seasonal watersheds allows

KHAMMAM DISTRICT
LAND USE/LAND COVER OF SELECTED MANDALS



0 3.256.5 13 19.5 26
Kilometers

FIG - 3

Index- Bonakal

- Agricultural Land-Crop Land-Cropped in 2 seasons
- Agricultural Land-Crop Land-Kharif Crop
- Agricultural Land-Crop Land-Rabi Crop
- Agricultural Land-Fallow
- Agricultural Land-Plantation
- Built Up (Rural)
- Built Up- Quarry
- Vegetated / Open Area
- Wastelands-Barren Rocky/Stony waste
- Wastelands-Scrub land-Dense scrub
- Wastelands-Scrub land-Open scrub
- Waterbodies-Canal/Drain
- Waterbodies-Reservoir/Tanks-Permanent
- Waterbodies-Reservoir/Tanks-Seasonal
- Waterbodies-River/Stream-Non Perennial
- Waterbodies-River/Stream-Perennial

Index –Chinthakani

- Agricultural Land-Aquaculture
- Agricultural Land-Crop Land-Cropped in 2 seasons
- Agricultural Land-Crop Land-Kharif Crop
- Agricultural Land-Crop Land-Rabi Crop
- Agricultural Land-Fallow
- Agricultural Land-Plantation
- Built Up (Rural)
- Wastelands-Scrub land-Dense scrub
- Wastelands-Scrub land-Open scrub
- Waterbodies-Canal/Drain
- Waterbodies-Reservoir/Tanks-Permanent
- Waterbodies-Reservoir/Tanks-Seasonal
- Waterbodies-River/Stream-Non Perennial
- Waterbodies-River/Stream-Perennial

Index – Madhira

- Agricultural Land-Crop Land-Cropped in 2 seasons
- Agricultural Land-Crop Land-Kharif Crop
- Agricultural Land-Crop Land-Rabi Crop
- Agricultural Land-Fallow
- Agricultural Land-Plantation
- Built Up (Rural)
- Built Up-Industrial
- Vegetated / Open Area
- Wastelands-Scrub land-Dense scrub
- Wastelands-Scrub land-Open scrub
- Waterbodies-Canal/Drain
- Waterbodies-Reservoir/Tanks-Permanent
- Waterbodies-Reservoir/Tanks-Seasonal
- Waterbodies-River/Stream-Non Perennial
- Waterbodies-River/Stream-Perennial

Index – Mudigonda

Index – Nelakondapalle

Index – Wyra

Table No. 2.1

Land Use/Land Cover of Bonakal Mandal In Khammam District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage with Respect to Mandal Total**
1	Agricultural Land-Aquaculture	17.36787458	0.109622
2	Agricultural Land-Crop Land-Cropped in 2 seasons	10919.29154	68.91983
3	Agricultural Land-Crop Land-Kharif Crop	2079.810081	13.12724
4	Agricultural Land-Crop Land-Rabi Crop	390.5125344	2.464817
5	Agricultural Land-Fallow	371.5096041	2.344875
6	Agricultural Land-Plantation	554.8222238	3.501899
7	Built Up	453.2986916	2.861108
8	Wastelands	313.6514752	1.97969
9	Waterbodies	743.2045334	4.690921
Total Mandal		15843.5	100.00

Table No. 2.2

Land Use/Land Cover of Chinthakani Mandal In Khammam District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	13830.61388	73.749769
2	Agricultural Land-Crop Land-Kharif Crop	2128.313796	11.348929
3	Agricultural Land-Crop Land-Rabi Crop	491.6729471	2.621776
4	Agricultural Land-Fallow	285.1389763	1.520463
5	Agricultural Land-Plantation	156.1678403	0.832743
6	Built Up	564.8618993	3.012045
7	Vegetated / Open Area	56.6857019	0.302268
8	Wastelands	343.7867468	1.833194
9	Waterbodies	896.1916126	4.778813
Total Mandal		18753.4	100.00

Table No. 2.3

Land Use/Land Cover of Madhira Mandal In Khammam District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	6451.9498	31.39459
2	Agricultural Land-Crop Land-Kharif Crop	9407.304177	45.77507
3	Agricultural Land-Crop Land-Rabi Crop	626.4107007	3.048056
4	Agricultural Land-Fallow	701.6905619	3.414361
5	Agricultural Land-Plantation	1185.761688	5.769806
6	Built Up	676.3384776	3.291
7	Vegetated / Open Area	32.62284416	0.15874
8	Wastelands	387.154494	1.883858
9	Waterbodies	1081.919195	5.264518
Total Mandal		20551.2	100.00

Table No. 2.4

Land Use/Land Cover of Mudigonda Mandal In Khammam District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	14252.85585	69.400537
2	Agricultural Land-Crop Land-Kharif Crop	3374.118326	16.429383
3	Agricultural Land-Crop Land-Rabi Crop	26.85706737	0.130773
4	Agricultural Land-Fallow	204.1384638	0.993999
5	Built Up	717.2120172	3.492276
6	Wastelands	357.6952999	1.741703
7	Waterbodies	1604.220282	7.811329
Total Mandal		20537.1	100.00

Table No. 2.5

Land Use/Land Cover of Nelakondapalle Mandal In Khammam District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	11398.18296	59.854818
2	Agricultural Land-Crop Land-Kharif Crop	5247.625078	27.556642
3	Agricultural Land-Fallow	261.4173531	1.37277
4	Agricultural Land-Plantation	76.81888874	0.403396
5	Built Up	770.3477477	4.045296
6	Wastelands	306.8391306	1.611292
7	Waterbodies	981.8189721	4.402625
Total Mandal		19043.1	99.25

Table No. 2.6

Land Use/Land Cover of Wyra Mandal In Khammam District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Aquaculture	17.21563656	0.123086
2	Agricultural Land-Crop Land-Cropped in 2 seasons	10844.12219	77.531669
3	Agricultural Land-Crop Land-Kharif Crop	1541.720054	11.022758
4	Agricultural Land-Crop Land-Rabi Crop	127.4723239	0.911382
5	Agricultural Land-Fallow	192.3666225	1.375354
6	Agricultural Land-Plantation	84.24188725	0.6023
7	Built Up	534.6169098	3.822323
8	Wastelands	187.0274929	1.337181
9	Waterbodies	457.9171043	3.273946
Total Mandal		13986.7	100.00

the cultivators to do seasonal cropping, that is the kharif crops. Some places near the seasonal water catchment areas are found to cultivate kharif crops. This covers of 5247.63 ha (27.56%) of land of the total mandal area. It implies that these places are well irrigated but because of temporary water availability it cannot be cropped twice a year and there is no scope for cultivating Rabi crops. However, because of the continuous irrigation facility, 11398.18 ha (59.85%) of the land is well cultivated in two seasons. 261.42 ha (1.37%) of the land is found to be fallow. They are found mostly in the southernmost part of the mandal (fig-3). About 16984.04 ha (89.19%) of the total land is categorized as agricultural land use. 770.35 ha (4.05%) of the lands are used for rural settlements and even some of these places are identified as quarries. The rural built up areas are distinctively populated in the mandal area. 306.84 Ha (1.61%) land remains unused and is marked as wasteland. Forest is absolutely absent in this mandal.

WYRA:

This mandal occupies an area of 13986.70 ha (Table No. 2.1). 12807.14 Ha (91.57%) of land of this mandal is used for agricultural purpose. Almost 475.13 ha (3.39%) of land is covered by waterbodies. This seems to be less when compared to the other mandals of the district 17.22 ha (0.12%) is of land used for aquaculture. And these aquaculture lands are also included in agricultural land use. Rest of the waterbodies constitute two major perennial streams passing longitudinally within the eastern regions of the mandal and other small and large seasonal or permanent surface waterbodies are found mostly in the northern region and in small patches within the rest of the mandal area. So, the feasibility of these running waterbodies and surface watersheds allow the croplands to be well irrigated. Hence 10844.12 ha (77.53%) of the total land is cropped in two seasons. Few of the lands of the mandal (1541.72 ha or 11.02%) are rain water dependent. This is because of the land elevation or lessmoisture containing capacity. But 192.37 hectares of land (1.38%) are found to be fallow. These are mainly seen near the rural built up areas. These lands may have planned to be transformed into residential land use in future. The total land used for agricultural purpose is a sum of 12807.14 hectares (91.57% of the total mandal area). See fig-3. And the total rural or quarry built up lands comprises a sum of 534.62 hectares (3.82%) of the total land area. Wastelands are seen covering an area of 187.03 hectares or 1.34% of the total land. Out of these, within the northern part of the perennial stream a large land parcel is found turned into a ravine. It seems the seasonal stream flows very quickly within this region and hence the land has become non-productive. This area can best be used for seasonal pisciculture as the land is shaped into a ‘U’ or ‘V’ curve. Also, the rest of the unused scrublands are found near the settlement areas or like a small mound within the stream. Forest cover is not seen anywhere within the mandal.

MAHABUBNAGAR DISTRICT

ALAMPUR:

Alampur mandal of Mahabubnagar District is one of the distinguishable mandal to be discussed. The mandal is spread over 112199.22 hectares of land within the district (Table No. 2.7). Out of the total area nearly one-third (31.44%) or 88203.90 hectares are covered by waterbodies. Out of these the major running water and catchment area that is widely spread over the north to south-east along the eastern border is Krishna River Reservoir and Tungabhadra River at the southernmost border. These two waterbodies are responsible for the soil of the entire mandal to have more moisture content. Also, these two perennial and non-perennial rivers have become the greatest source of water for irrigation into the agricultural lands. Other small non-perennial small rivers or rivulets are also seen in the northern and south-western region of the mandals. Since one-third (completely eastern part) of the mandal area is covered by water, 65.35% (18331.40 Ha) out of the rest available lands are marked as agricultural lands (Fig-4). Almost 16.18% of the lands along with the river bank are cropped in two seasons, because of assured water supply. Because of maximum moisture content in the soil, monsoon dependent of kharif crops are hardly found. Only 1.66% of lands are kharif cropped. But rest of the 43.2% of land (12115 Ha) are used for rabi crops as the moisture content is more. So completely the western, northern and southern parts are rabi cropped. Only 4.3% of the lands are found fallowed along the river. Forest cover is conspicuously absent throughout the entire mandal. Unlike all other mandals, small patches of rural land use are seen here and there. 1.3% lands are found wastelands and are very near to the fallowed agricultural lands. Together these lands and salt affected lands can be used for agro-chemical or beverage industries as the river is very near. It can be suggested to grow artificial forests for the soil conservation or aquaculture and aqua-industries also can be developed there.

ITIKYAL:

The total area of the mandal is 29615 Ha (Table No. 2.8). Nearly 6.35% of lands are covered by waterbodies. These are mainly the north-eastern river catchment area (Mixed Perennial, Non-Perennial and Seasonal) and some large seasonal surface watersheds in the western part of the mandal. A long canal also divides the mandal longitudinally. Because of having many watersheds on the ground and irrigation facility, nearly 90% of the total lands (26222 Ha) are under agricultural use (Fig-4). 35.15% (10412.6Ha) of the agricultural lands close to the eastern river bank are cropped in two seasons. Being high lands, some areas in the north-west, central and south –west are still monsoon dependent. 18% (5348Ha) of the lands are kharif

cropped. But 31% (9192.65Ha) of the lands are rabi cropped. These areas are mainly the South-central and southern parts of the mandal. 4.28% of the lands (1269Ha) are found to be fallowed. These fallow lands are mostly found near the southern industrial built up area and some of them are seen near to the river catchment area and the salt affected areas and wastelands. These can be in future, used for residential purpose as these are very close to the rural and industrial settlement areas. 3.28% of the lands are found unused and marked as wastelands. Area under forest cover is absent throughout the entire mandal. These unused lands could be reused for animal farming; industrial set ups, Agricultural Store Houses or Residential purpose also. Stony or rocky barren lands can be excavated for quarrying purpose. Even if the kharif cropped areas could be properly irrigated then there more crop production can be expected.

MANOPAD:

The mandal Manopad is spread over 28825.4 Ha of land in Mahbubnagar District (Table No. 2.9). 7.83% (2257.75Ha) of the mandal total is covered by waterbodies (Fig-4). Non-perennial and perennial streams, seasonal are nicely distributed in the mandal. Canal irrigation is also found very well distributed. A very large part of the mandal in the north is covered by a seasonal and permanent watershed as a part of Krishna River. These well allocated water resources have made the lands high intensive of crop production. A very negligible amount of land is marked as wasteland otherwise rest of the 90% lands is under agricultural use. The areas very close to the irrigation canals, streams and river and water catchments, are cropped in two seasons. 31.71% of the lands (9142.5Ha) are used in this way. Because of rich availability of water supply to the crop fields, only 1% of the lands are monsoon dependent and hence kharif cropped. Rest of the 54.75% of the lands are rabi cropped. 15777.35Ha of lands are under the use of rabi crops. Since most of the lands are used for agriculture, so small rural settlements are found everywhere within the agro fields. Avery small parcel of land is marked as a quarry in the south and a very small parcel is marked as industrial in the north part of the mandal. Near to that industrial built up area, some extent of lands is seen salt affected and remained unused. These areas can be used for setting up agro industries as the mandal is rich of agro products. Even Animal food and seeds development research centers, store houses, food reprocessing industries, Diary product industries could be proposed there. Forest cover is completely absent in the mandal.

PEBBAIR:

Pebbair mandal of Mahbubnagar is stretched over 28130.16Ha of geographical extent (Table No. 2.10). Very unlikely to Almpur mandal, 5430.5Ha of the total land (nearly 20%) is covered by waterbodies. The main part of these waterbodies is the water catchment of Krishna River flowing along the western border to the southern reservoir

(Fig-4). A canal also passes through the mandal from north to south-east. Other large seasonal and small permanent ground watersheds are seen in the east and center of the mandal. Being in a semiarid agroclimatic zone, most of the surface waterbodies are seasonal and the areas along the eastern border are a little high and dry lands. 75% (21107Ha) of the mandal total are under agricultural use. Nearly 9966.5Ha (35.5%) of the areas which are close to the watersheds are cropped in two seasons. These areas are irregularly shaped and scattered within the central to southern part of the mandal. Nearly 3714.5Ha (13.23%) of the total lands are rain fed. But 5500Ha or 19.5% of the lands are rabi cropped because of the closeness to the irrigation canal and permanent surface watersheds. Because of high altitude and dry climate, around 6.5% or 1809Ha of lands in the north-eastern and eastern regions are found fallowed. A small patch is seen as industrially used in the western region near to the river bank. Only 2.33% of lands are used for human settlements. Also 3.2% of the lands 901.4Ha lands in the eastern region are marked as wastelands. These areas are mostly scrub covered. Since water availability is less in this part of the mandal, these places could be used for commercial plantation or artificial afforestation. This afforestation may help in the rise of the underground water table, moister content in the soil and affect the annual rainfall and climate also.

WADDEPALLE:

Waddepalle mandal in Mahbubnagar is spread over 26622.3Ha of land. Nearly 6% of the lands are water covered (Table No. 2.11). These waterbodies are mainly the river flowing latitudinal along the southern border of the mandal and the stream flowing in middle longitudinally. A number of canals also flow within the agro fields from west to east centrally. Small seasonal tanks are seen at some of the areas. 23512.7Ha of lands out of the mandal total (nearly 90%) is under agricultural use (Fig-4). No forest cover is seen in the mandal. Nearly 48% of the lands close to the irrigation canal and river bank are cropped in two seasons. But few of the high lands in the north, west and south-west parts are monsoon dependent. So, these 3024.75Ha of lands (11.36%) are kharif cropped. Areas which are properly irrigated nearly 5828.7Ha (21.9%) lands are rabi cropped which are found in the eastern, central and south-western regions very close to the canals and rivers. 1986Ha or 7.46% of the lands in the northern and western highland areas are seemed to be fallowed. Since few quarries and industrial set ups are there in the mandal, people might be engaged there instead of agriculture. But these fallow lands could be irrigated and restarted for cultivation of rabi crops as the canal passes near these places. A large parcel of rocky wasteland is seen in the western border of the mandal. Most of the wastelands are mainly salt affected areas. These again could be used for industrial development. Forest cover is seen nowhere in the mandal.

MAHBUBNAGAR DISTRICT
LAND USE/LAND COVER OF SELECTED MANDALS

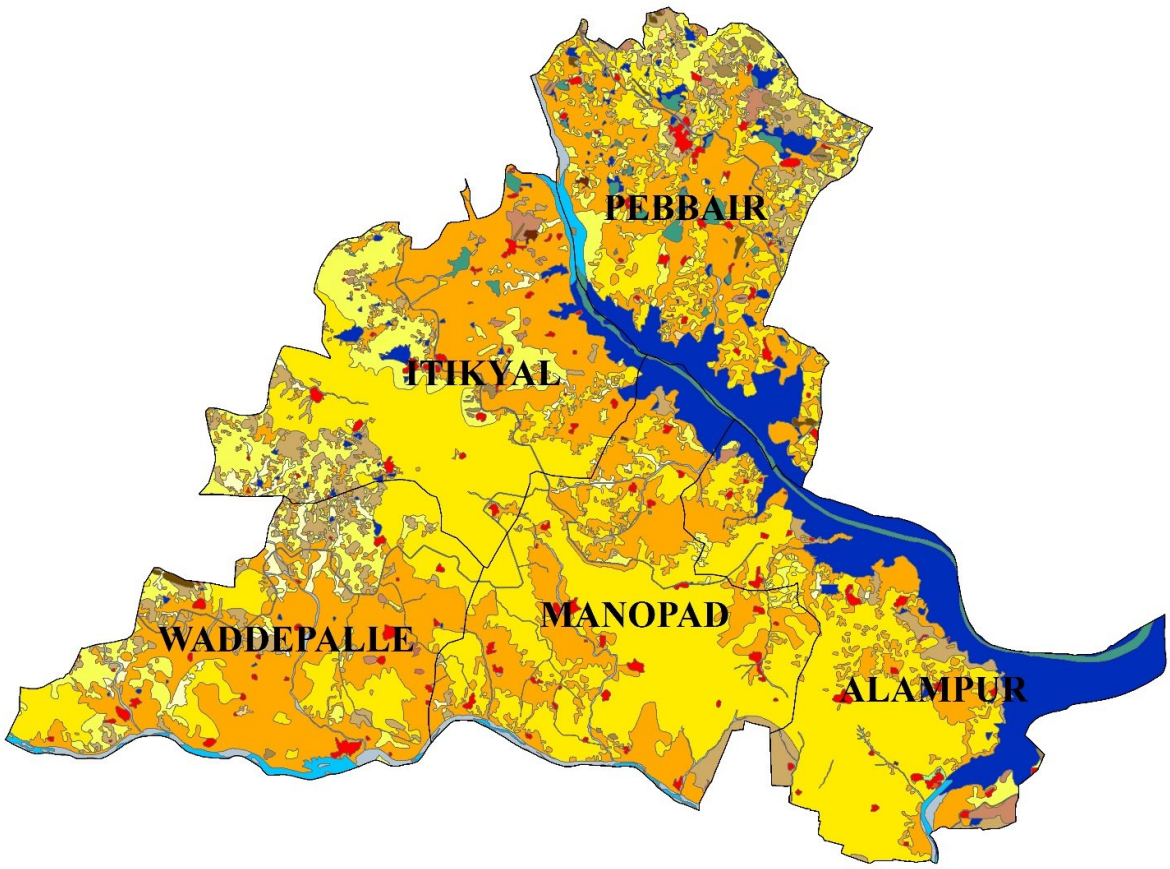


FIG - 4

Index – Alampur

Index – Itkyal

Index – Manopad

Index – Pebbair

Index – Wadepalle

Table No. 2.7

Land Use/Land Cover of Alampur Mandal In Mahbubnagar District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	4539.17	16.18
2	Agricultural Land-Crop Land-Kharif Crop	466.78	1.66
3	Agricultural Land-Crop Land-Rabi Crop	12115.06	43.19
4	Agricultural Land-Fallow	1210.38	4.31
5	Vegetated / Open Area	40.88	0.14
6	Built Up	488.6	1.74
7	Wastelands	369.10	1.31
8	Waterbodies	8820.39	31.44
Total Mandal		28050.38	100.00

Table No. 2.8

Land Use/Land Cover of Itikiyal Mandal In Mahbubnagar District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	10412.59	35.16
2	Agricultural Land-Crop Land-Kharif Crop	5347.96	18.06
3	Agricultural Land-Crop Land-Rabi Crop	9192.65	31.04
4	Agricultural Land-Fallow	1269.04	4.28
5	Built Up	538.72	1.82
6	Wastelands	972.90	3.28
7	Waterbodies	1881.20	6.35
Total Mandal		29615.1	100.00

Table No. 2.9

Land Use/Land Cover of Manopad Mandal In Mahbubnagar District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	9142.52	31.71
2	Agricultural Land-Crop Land-Kharif Crop	310.45	1.08
3	Agricultural Land-Crop Land-Rabi Crop	15777.38	54.73
4	Agricultural Land-Fallow	608.021	2.11
5	Built Up	537.19	1.86
6	Wastelands	192.09	0.66
7	Waterbodies	2257.74	7.83
Total Mandal		28825.4	100.00

Table No. 2.10

Land Use/Land Cover of Pebbair Mandal In Mahbubnagar District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	9966.55	35.43
2	Agricultural Land-Crop Land-Kharif Crop	3724.43	13.24
3	Agricultural Land-Crop Land-Rabi Crop	5500.75	19.55
4	Agricultural Land-Fallow	1809.66	6.43
5	Agricultural Land-Plantation	105.52	0.37
6	Built Up	655.50	2.33
7	Vegetated / Open Area	35.79	0.12
8	Wastelands	901.43	3.20
9	Waterbodies	5430.52	19.30
Total Mandal		28130.2	100.00

Table No. 2.11

Land Use/Land Cover of Wadepalle Mandal In Mahbubnagar District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	12650.31	47.58
2	Agricultural Land-Crop Land-Kharif Crop	3024.73	11.36
3	Agricultural Land-Crop Land-Rabi Crop	5827.67	21.89
4	Agricultural Land-Fallow	1986.20	7.46
5	Agricultural Land-Plantation	23.76	0.089
6	Built Up	533.89	2.01
7	Wastelands	996.70	3.74
8	Waterbodies	1579.02	5.93
Total Mandal		26622.3	100.00

NALGONDA DISTRICT

KODAD:

The mandal is extended over an area of 24665.85 hectares of land in Nalgonda District (Table No. 2.12). 3.76% of the land (927.9 Ha) is covered by waterbodies. The major seasonal source of running water here is the perennial stream flowing south-north wise through the eastern border of the mandal (fig-5). And another permanent source of running water which is mostly used for agricultural irrigation purpose is the canal which flows to the south-east from the south-west and the southernmost regions of the mandal. The western permanent ground watershed and all the other seasonal water catchment areas disseminate within the mandal. The availability of water supply has facilitated around 14420 Ha or 58.46% of land spread widely over the mandal to be cultivated in two seasons. But because of these permanent sources of ground watersheds are small in number many of the places in the central and northern region of the mandal are found to be rain water dependent. And hence there is kharif crop. This constitutes a total of 5635.18 Ha or 22.85% of the total available land. These places can be more productive if irrigated in a better way. Fallow lands are very less. And some of the places are used for agricultural plantation. This is also very small in size, only 415.78 ha or 1.69% of the total land. Many quarries are found which are well populated within the entire mandal and some industrial land use is also seen. Hence a very large parcel of land is found to be compact built up area in the west-central region. And other rural or sparse settlement areas are seen everywhere in the mandal. About 20616.03 ha (83.58%) of land is used for agriculture, and 1930.09 ha (7.82%) of the total land is used for rural, compact, sparse, industrial and other settlement purpose. Wastelands and open vegetated lands together constitute a sum of 1191.84 ha (4.83%) of lands. These can be transformed to public facilitation centres digging bore wells will facilitate better irrigation of wind and solar power generating projects can also be established kharif cropped areas and also the need of power to lift the underground water could be managed. Further few of the places can be used for making water sumps or pits to absorb the rain harvested water. No forest cover is present anywhere in the mandal.

MOTHEY:

The mandal is extended over an area of 20630.88 ha of land in Nalgonda District (Table No. 2.13). Broadly four types of land use can be categorized here namely agricultural built up land, wastelands and waterbodies. This mandal is a bit richer in water availability. When compared to other mandals 1216.86 a (nearly 6%) of the total land is covered by drainage network and waterbodies. Three small latitudinal canals flow in to the croplands in the north, north-west and south-central regions. Seasonal and permanent large and small surface watersheds help in irrigating the lands throughout the year. Hence, places surrounding to these water catchmentsare adequatelyirrigated and cropped in two seasons.It can be seen in the (fig-5) that although the watersheds are well distributed and possibly the lands which are cropped in twoseasons areadequately irrigated the opposite side of these lands are still rain dependent, and kharif cropped. In this practice 10773.77 ha (52.22%) of land are used for cropping in two seasons and 6903.16 ha (33.46%) for kharif crops. Lands used for

agricultural plantation are very less. But fallow lands are found to be 2.59% of the total land or equal to 533.66 ha. Since nearly 33.5% of the lands are kharif cropped, annual production is also less. This has to be taken into account and the places need to be well planned for irrigation. Fallow lands can be used for animal husbandry, grazing fields, poultry farming or honey bee farming. Industrial land use is also found in one or more places. Moreover, 802.26 ha or 3.89% of land is used for human settlements. Unlike other mandals, here also 275.47 Ha or 1.34% of land is found to be wasteland. Forest cover is as usually not found anywhere in the mandal.

MUNAGALA:

The total area of the mandal is extended over 14540.40 Ha of land in Nalgonda District (Table No. 2.14). Very similar to the previous mandal, the lands of this mandal are only classified into four broad categories; Agricultural land built up, area Wastelands and Waterbodies. Forest cover, tree clad or vegetated areas are absolutely absent in this mandal. The lands are mostly used for agricultural purpose. Around 677.15 Ha or 4.66% of the total mandal is covered by waterbodies. Two small canals can be identified on the fig-5, which flow through the northern and south-eastern places. Large and small seasonal and permanent stationary surface waterbodies are scattered here and there. These water bodies and canals have a significant role in rural agriculture. Similar to the previous mandals that we have discussed, some places surrounding these waterbodies are plains and opposite to that the lands are may be a little higher in ground elevation. So the plain areas are found to be well irrigated and hence cropping is practiced in two seasons. Moreover 5474.47 Ha (37.65%) of land is cropped in two seasons which is very less when compared to the other mandals. And as the irrigated water can't reach the high croplands, there the cultivators mainly depend on rain fed crops. So 5948.72 Ha (40.91%) of the lands are kharif cropped. This is the reason why there is low production of crops in the mandal. Even rabi crops are cultivated on very negligible amount of land. It can be seen on the map that around 1596.76 ha (10.98%) of lands are fallow. These are seen in the northern, south-western, south-eastern and the west-central regions. This is much more compared to the other mandals of the district. Nearly 41% of the lands kharif crop is cropped in one season.The mandal need a better irrigation plan to be implemented. If canal irrigation is not so feasible, then digging of bore wells or creating artificial ponds or pools or water sumps can help to certain extent. A few of the places can be used for rabi crops also. For these fallow lands, the best plan that can be suggested is to go for commercial plantation *viz. Bamboo, Cattle feeding Grass, Teak plants, Mango and other.* Converting fallow lands into crop lands incurs a huge expenditure. But this expenditure can be avoided if plantation could be grown there and animal husbandry or poultry farming could be carried on. This way the extracts of the animals and birds can help in increasing the fertility of the soil and the natural organic bio fertilizer being decomposed makes the upper soil soft and moisturized. Since waterbodies

arenot adequately found within these fallow lands, hence proposing industrial units to be established there is meaningless.

NALGONDA DISTRICT
LAND USE/LAND COVER OF SELECTED MANDALS

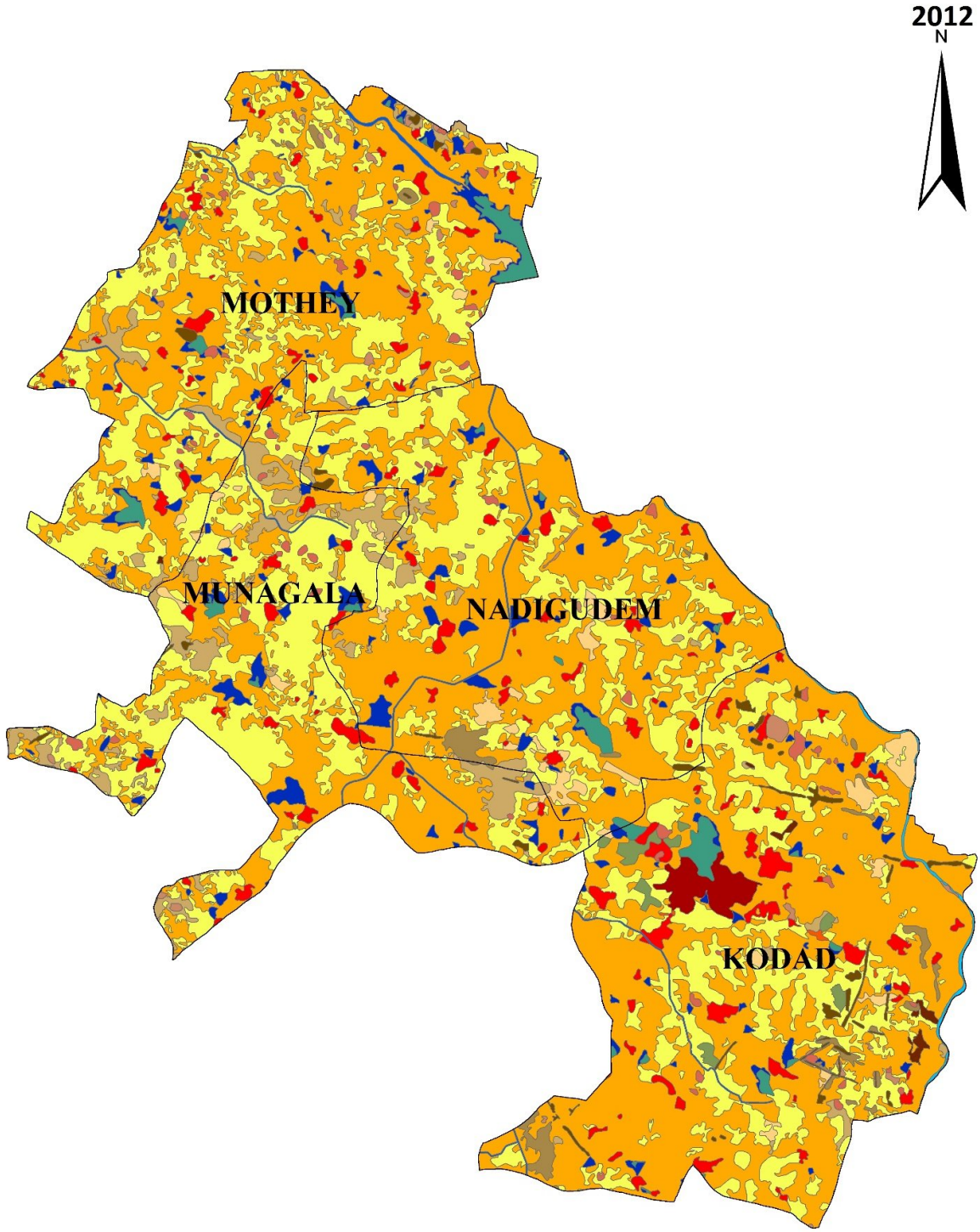


FIG - 5

Index – Kodad

Index – Mothey

Index – Mungala

Index – Nadigudem

Table No. 2.12

Land Use/Land Cover of Kodad Mandal In Nalgonda District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	14419.94257	58.461152
2	Agricultural Land-Crop Land-Kharif Crop	5635.18379	22.846092
3	Agricultural Land-Fallow	145.130692	0.588387
4	Agricultural Land-Plantation	415.7757596	1.685633
5	Built Up	1930.089602	7.824944
6	Vegetated / Open Area	308.3154925	1.249969
7	Wastelands	883.5208005	3.581959
8	Waterbodies	927.8954654	3.761862
Total Mandal		24665.9	100.00

Table No. 2.13

Land Use/Land Cover of Mothey Mandal In Nalgonda District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	10773.76871	52.221564
2	Agricultural Land-Crop Land-Kharif Crop	6903.163959	33.460345
3	Agricultural Land-Fallow	533.6612007	2.586711
4	Agricultural Land-Plantation	125.7000219	0.609281
5	Built Up	802.2567932	3.888621
6	Wastelands	275.473343	1.335248
7	Waterbodies	1216.856851	5.89823
Total Mandal		20630.9	100.00

Table No. 2.14

Land Use/Land Cover of Mungala Mandal In Nalgonda District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	5474.471388	37.650074
2	Agricultural Land-Crop Land-Kharif Crop	5948.718551	40.911657
3	Agricultural Land-Crop Land-Rabi Crop	4.615109128	0.03174
4	Agricultural Land-Fallow	1596.758779	10.981533
5	Agricultural Land-Plantation	161.5580726	1.111098
6	Built Up	591.4573931	4.067683
7	Wastelands	85.66751245	0.589169
8	Waterbodies	677.153133	4.657046
Total Mandal		14540.4	100.00

Table No. 2.15

Land Use/Land Cover of Nadigudem Mandal In Nalgonda District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	10766.47318	57.11703
2	Agricultural Land-Crop Land-Kharif Crop	5482.610527	29.085702
3	Agricultural Land-Fallow	332.6206005	1.76458
4	Agricultural Land-Plantation	467.8996736	2.482246
5	Built Up	630.9174315	3.347069
6	Vegetated / Open Area	0.258276372	0.00137
7	Wastelands	282.4804438	1.498582
8	Waterbodies	886.5874679	4.703421
Total Mandal		18849.8	100.00

A few quarries are found in the central region. Rural settlements are discreetly scattered in the mandal within the croplands. A total of 591.46 Ha (4.07%) of land is used for settlements and quarries. Wastelands are not found here, like all other mandals of the district this mandal also has no forest coverage.

NADIGUDEM:

Nadigudem is one of the significant mandals of Nalgonda District from the agricultural point of view. The mandal is extended over 18849.848 hectares of land within which 886.587 Ha (4.703%) are concealed by waterbodies and 17049.604 Ha (90.45%) of land is used for agriculture (Table No. 2.15). A perennial stream or river is seen flowing through the eastern border of the mandal while a canal divides the mandal into two fig-5, flowing longitudinally in the middle of the mandal. These two running waters play a major role in irrigating the croplands. On the other side, a very large permanent ground stationary watershed is seen within the southern region and other small or little bigger seasonal and permanent water catchments are found scattered within the mandal. The perfect distribution of these running and stationary waterbodies has capacitated agricultural lands to be highly productive. This is the reason, why almost 10766.473 Ha (57.117%) of the total land is well cultivated in the two seasons. However, still some of the places are not well irrigated, and 5482.611 Ha (29.086%) of lands are rain dependent. These are spread throughout the mandal. These places have become less productive. There artificial water catchment areas can be dug so that they can be used for lift irrigation purpose in the future. So that the lands could be more productive. Rabi cropped areas are not seen anywhere in the mandal.332.621 hectares of land (1.765% of the mandal total) are found to be fallow. These lands are mostly found near the agricultural plantation areas and kharif cropped areas. So, the lands can be best used for wind farms or solar power generation centers which would help the cultivators with electricity supply for lift irrigation or running the motors for sprinkling of water into the crop fields. Because of less availability of water supply in the kharif cropped lands, few more places within these lands are used for agricultural plantation. Around 467.900 hectares of land (2.482%) are used for this purpose. These places can not only be used as agricultural plantation, but mixed agriculture can also be practiced. Poultry farming or cattle farming could be mixed with these plantations. Rural settlements are populated throughout the mandal. A total of 630.917 hectares (3.347%) of land is used for built up purpose. Forest cover is absent in the mandal. Only a small patch of land is found to be open vegetated area.

WARANGAL DISTRICT

JANGAON:

Jangaon mandal of Warangal district is geographically extended over 20569.2ha of land (Table No. 2.16). About 5% of the land (1022.7ha) is covered by waterbodies. Two large permanent surface water catchments exist in the central and south-east region surrounded by several other seasonal waterbodies. These seasonal surface waterbodies are scattered throughout the mandal area and nearly absent in the northern and western part (Fig-6 A). A non-perennial stream flows through the central region spread north-west to south-east. Three small irrigation canals flow in the extreme north and eastern region. The lands of this mandal seem not to be well irrigated. Still, 77% of the total land is under agricultural use. 17.25% of the total land (3549.02ha) are cropped in two seasons and are close to the surface waterbodies. But 3839.38ha of lands (18.67%) which are less irrigated and close to the seasonal waterbodies, are mainly dependent on monsoon. So these areas are under kharif cropped. Nearly 3% of the total lands are found to be used for rabi crops. But 7799ha (38%) of the total lands are classified as fallow lands. May be the people are engaged in quarrying activities. And very significantly a very large land parcel in the south-east region is marked as compact built up area surrounded by sparse built up areas. This area seems to be getting urbanized. This might be the other reason for people getting involved in urban activities instead of agricultural activity. Small rural land parcels are seen here and there in the mandal. In this way about 5.3% of the total mandal area is used for human settlements. 2653.2ha 13% of the total land are wastelands. Most of the wastelands are scrub covered.

MARIPEDA:

Maripeda is one of the significant mandal of Warangal District having an area of 27278.53 hectares of land (Table No. 2.17). 5.63% or 1535 hectares of the total mandal is covered by waterbodies and drainage network. One major non-perennial river runs through the north-eastern region parallel to the border. This is probably the main source of irrigation to the crop fields nearby it. Another two canals are flowing diagonally within the central and south-western region (Fig-6 A). These three running waterbodies play the most important role in irrigation. In other hand mostly, seasonal ground watersheds are found in many numbers here and there. Permanent watersheds are seen very few in numbers. As everywhere seasonal watersheds and canal irrigated water are available, most of the croplands are yielded twice a year. About 11183.54 hectares of land that is 41% of the mandal total are cropped in two seasons here. Some of the agricultural lands are monsoon dependent. May be because of highlands are they. Nearly 4749.03 hectares or 17.41% of the agricultural lands are under practice of kharif cropping activity. Since most of the croplands are cropped in two seasons, so

only rabi cropped areas are seen very less. Only 1350.75 hectares of lands (nearly 5%) are rabi cropped. Although a very good facility of irrigation is there to the croplands,

WARANGAL DISTRICT
LAND USE/LAND COVER OF SELECTED MANDALS

2012

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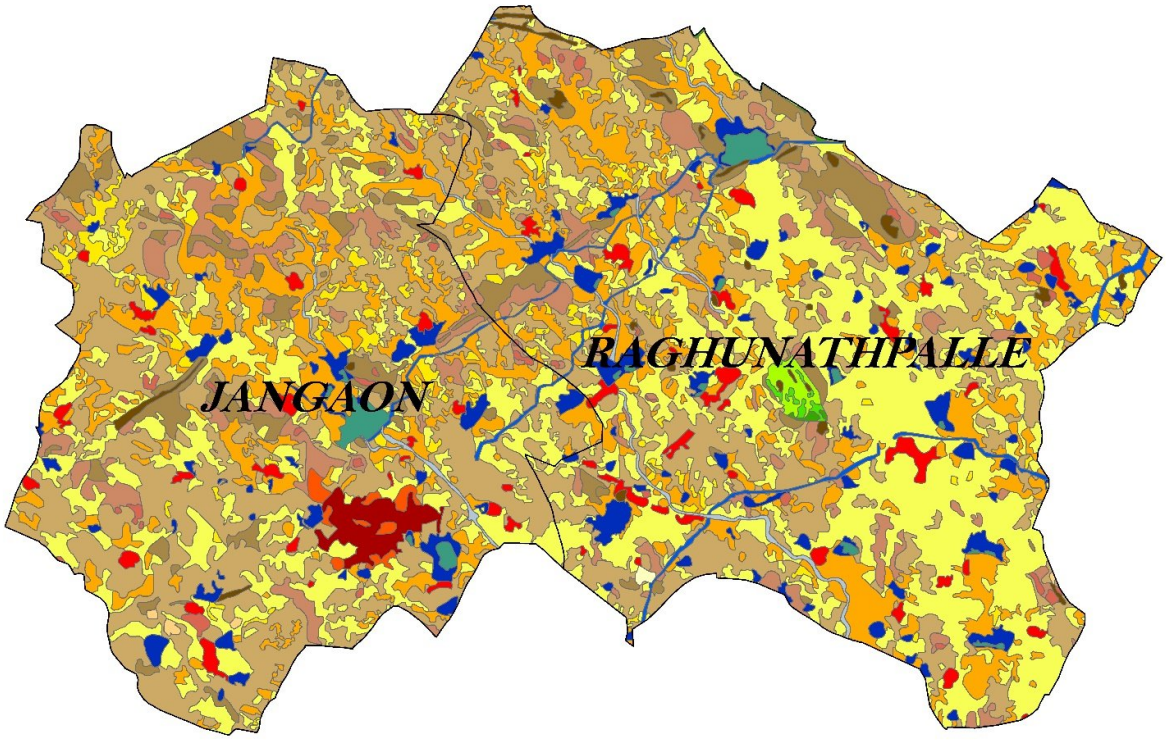

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Kilometers

FIG- 6 (A)

WARANGAL DISTRICT

LAND USE/LAND COVER OF SELECTED MANDAL

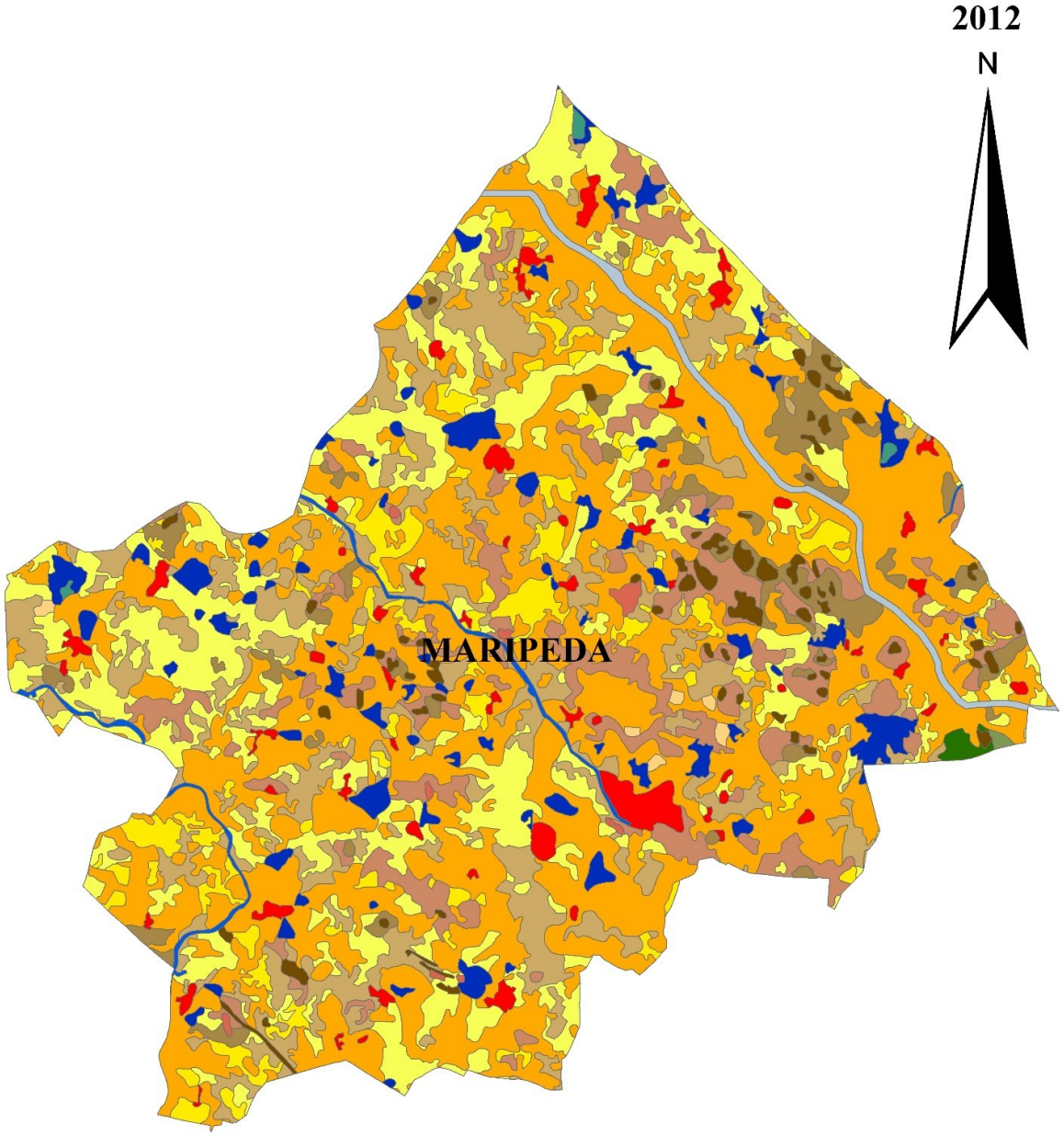


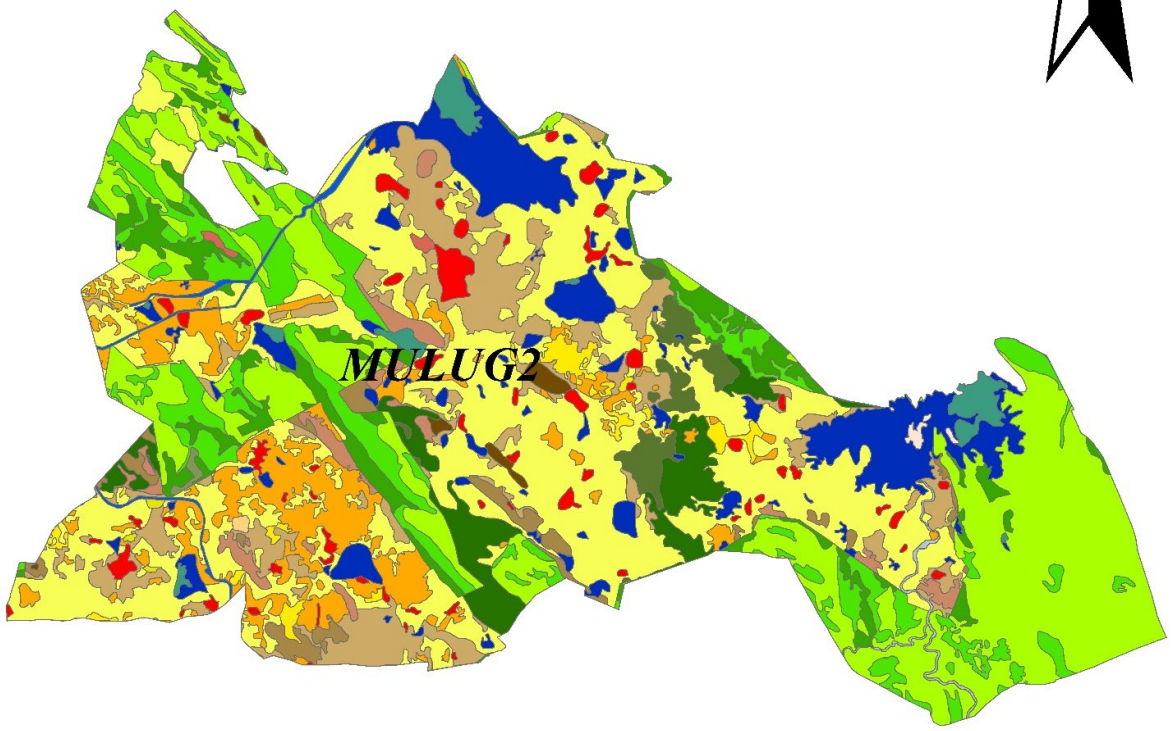
FIG- 6 (B)

WARANGAL DISTRICT

LAND USE/LAND COVER OF SELECTED MANDAL

2012

N



0 1.5 3 6 9 12

Kilometers

FIG- 6 (C)

Index – Jangaon

Index – Maripeda

Index – Mulugu

Index – Raghunathpalle

Table No. 2.16

Land Use/Land Cover of Jangaon Mandal In Warangal District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	3549.02	17.25
2	Agricultural Land-Crop Land-Kharif Crop	3839.38	18.67
3	Agricultural Land-Crop Land-Rabi Crop	585.06	2.84
4	Agricultural Land-Fallow	7799.01	37.92
5	Agricultural Land-Plantation	32.19	0.16
6	Built Up	1088.68	5.29
7	Wastelands	2653.20	12.90
8	Waterbodies	1022.70	4.97
Total Mandal		20569.2	100.00

Table No. 2.17

Land Use/Land Cover of Maripeda Mandal In Warangal District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	11183.54	41.00
2	Agricultural Land-Crop Land-Kharif Crop	4749.03	17.41
3	Agricultural Land-Crop Land-Rabi Crop	1350.75	4.95
4	Agricultural Land-Fallow	3758.08	13.78
5	Agricultural Land-Plantation	55.55	0.20
6	Built Up	761.78	2.79
7	Tree Clad Area-Dense/Closed	49.25	0.18
8	Tree Clad Area-Open	13.10	0.05
9	Wastelands	3822.43	14.01
10	Waterbodies	1535.01	5.63
Total Mandal		27278.5	100.00

Table No. 2.18

Land Use/Land Cover of Mulugu2 Mandal In Warangal District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped more in 2 seasons	25.67	0.07
2	Agricultural Land-Crop Land-Cropped in 2 seasons	2691.77	7.22
3	Agricultural Land-Crop Land-Kharif Crop	10473.86	28.09
4	Agricultural Land-Crop Land-Rabi Crop	431.67	1.16
5	Agricultural Land-Fallow	3374.10	9.05
6	Agricultural Land-Plantation	21.11	0.06
7	Built Up	855.14	2.29
8	Forest	12365.00	33.16
9	Tree Clad Area-Dense/Closed	1335.85	3.58
10	Tree Clad Area-Open	586.00	1.57
11	Wastelands	1377.46	3.69
12	Waterbodies	3752.78	10.06
Total Mandal		37290.4	100.00

Table No. 2.19

Land Use/Land Cover of Raghunathpalle Mandal In Warangal District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	4347.10	17.43
2	Agricultural Land-Crop Land-Kharif Crop	8562.69	34.34
3	Agricultural Land-Crop Land-Rabi Crop	349.60	1.40
4	Agricultural Land-Fallow	6272.14	25.16
5	Agricultural Land-Plantation	18.15	0.07
6	Built Up	724.32	2.90
7	Forest	217.70	0.87
8	Wastelands	2703.17	10.84
9	Waterbodies	1739.04	6.97
Total Mandal		24933.9	100.00

still 3758.08 hectares (13.78%) of lands are found to be fallowed. These fallow lands are found everywhere within the mandal. And very similarly 3822.43 hectares of wastelands (14%) close to these fallow lands are seen. This way a net 7580.51 hectare or 27.78% of lands have become unproductive. Here, if the fallowed lands are not properly irrigated, these can be planned for agricultural plantations *viz. Dates, Mango, Citrus plants etc…* So that economically these could be more productive and also could be planned for mixed cultivation, *viz.* animal husbandry or commercial domestic bird culture. Some places are found to be mentioned as quarries. So, it directly indicates that some people must be engaged in these quarrying activities. This might be the cause of growth of fallow agricultural lands. Unlike all other mandals, here also rural set ups are well-distributed all through the mandal. About 761.78 hectares of lands (2.79%) are used for built up purpose inclusive of quarries therein.

MULUGU:

Mulugu mandal of Warangal District is spread over 37290.41 hectares of land enriched with forest resources (Table No. 2.18). Moreover 14286.84 hectares of land (38.31%) is covered by forest and clad with trees. These forest and clad areas are stretched throughout the north-west to south and the entire eastern region. Only a very small patch is surrounded by the eastern and east-central forest region. Since more than two-third of the mandal area is covered by forest, the land neither be used for crop cultivation nor for settlement purpose. Of the rest 62% of the land available again 3752.78 hectares (10.06%) is covered by waterbodies (Fig-6 B). Two major non-perennial surface watersheds that can be expanding four times its usual size in monsoon season are seen in the north and eastern part. The eastern permanent and seasonal large water catchment area is surrounded by forest in the east and croplands to the south. A non-perennial small river flows through the croplands and the forest in the eastern region. Two other small canals flow through the western croplands and from the northern permanent water catchment to the north-western croplands through the north-west forest. Since the mandal has more natural greenery or forest cover, so it can be easily understood that rain fall is very good water gets stored in many seasonal surface water catchments within the mandal. Many small, medium and large seasonal waterbodies are seen scattered here and there in the mandal. Almost 50% of the total mandal lands are covered by forest and waterbodies, the remaining half of the total land nearly i.e. 17018.18 hectares of land (45.63%) is used for agriculture. Very negligible amount of area is cropped for more than two seasons within the south-west region. Some places of the south-west and west-central parts are used for cropping in two seasons because of the canal irrigation. It is observed that only 2691.77 hectares of land (7.22%) are cropped in two seasons. Because of seasonal availability of water from the seasonal water catchments for supply into the croplands for most of the other part of the agricultural lands, it is seen these places are mainly rain water dependent. So kharif crops are cultivated there. Mostly these kharif cultivated croplands are strewn in the south-west, surrounding to the northern large water catchment and the eastern water catchment areas. These lands can be used for rabi crops if the water could be supplied through irrigation into the croplands from the permanent waterbodies. As few of the places are used for rabi crops and agricultural plantation.

Mostly the agricultural lands surrounding the settlement areas and land close to the forest are marked as fallow lands.

Thus 9.05% or 3374.10 hectares of land became unproductive. Only 855.14 hectares of lands (2.295) are occupied for human settlements out of which few of the places are identified as quarries and rest are rural built up areas. The land use pattern can be improved here in several ways. New quarries or mines can be identified after a keen search within the largely spread forest areas. Fallow and kharif cropped lands can be reused by well-planned irrigation models. A well-established forest inventory system is required for forest management and resource utility. Large perennial and non-perennial watersheds can be used for aquaculture seasonally. Small patches of wastelands are also found in some places.

RAGHUNATHPALLE:

Raghunathpalle mandal is spread over 24934 ha of land in Warangal District (Table No. 2.19). Nearly 7% of the total land is covered by waterbodies. These waterbodies are mainly either permanent or seasonal surface water catchments scattered all over the mandal area. Long non-perennial rivers run parallel along with the north-west to south-west mandal boundary and small non-perennial streams are seen within the north-central region of the mandal (Fig-6 C). Another two major sources of water are the canals, flowing in the lower northern and upper southern region from north-east to south-west. Out of the total land use, 78.41% is classified as Agricultural lands, which are thoroughly distributed throughout the entire mandal. The well distributed water sources have facilitated the lands to be cropped in two seasons. So, most of these double cropped areas (4347ha or 17.43% of the total land) are found near the waterbodies. Area under rabi crops are very less. Rather the interior and central regions of the mandal are Kharif cropped. This is because of the sources of water for irrigation are seasonal surface waterbodies. Hence these places are mainly dependent on monsoon. Almost 8563ha (34.34%) lands are dependent on rain feeding. Although the agricultural lands are well irrigated, only 25.16% of the total lands are fallowed. This is a major drawback found in the land use activity. May be the lands are less fertile or high lands or less irrigated. It can be predicted the people might be engaged in quarrying instead of agriculture, because of the unavailability of rain or irrigated water facility for a period of years. Quarries are found in small parcels of lands in the mandal. Unlike all other mandals this mandal has most of the lands under agricultural use, so only rural built up areas were seen. A small patch of deciduous forest area covering only 217.7ha of land exists in the central region of the mandal. 2703.17ha (10.84%) of land remained unused and marked as wastelands. Most of these wastelands are covered by scrubs. Even some of the places are covered by rocks or stones and became unused. In this context it can be suggested to turn these rocky or stony lands into stone quarries, so that the places could be excavated and later in time could be planned for some other use.

GUNTUR DISTRICT

BHATIPROLU:

Bhatiprolu is one of the most significant mandals of Guntur District spread over 9586.65 Hectares of land within the district of which 8518.07 Hectares (nearly 89%) are used for agricultural purpose (Table No. 2.20). This indicates that the people mainly depend on agriculture and no other source of earning. This is because of the rich availability of water resources and very good drainage network. 6% of the total land is covered by water bodies including a non-perennial river passing through the eastern most border, perennial rivulet flowing south-north and streams through the central and eastern part of the mandal (Fig-7). Permanent and seasonal watersheds are also found in different places of the mandal. And the most important source of irrigation is the north-west and north to south-east flowing canals. Most of the mandal area is cropped two seasons, because of the irrigation facility, stable and seasonal watersheds and seasonal streams. From the above discussion it becomes clear that fallow lands are hardly found and wastelands and forest cover are not found in this mandal. Because of maximum cultivation, only rural built up places are seen everywhere in the mandal. More than 5% land of the mandal (493.32 Hectares) is used for rural settlements. Nearly 53.44 Hectares of land is classified as fallow; this land can be used for agro based industrial development sector, rather than reusing it for agriculture. It's because, the installation of any agro-based industries within such a rich cultivating mandal can further regulate the production or reproduction, processing or reprocessing of the crops and can also improve the economy of the people by inviting the employment sector.

CHERUKUPALLE:

Cherukupalle is another significant mandal extended over 9823.70 Hectares of land parcel within the district (Table No. 2.21) and agro-productive as can be seen in the fig-7. This is adjacent to Bhatiprolu mandal. Three types of land use have been classified as seen in the map, namely agricultural, built up land and waterbodies. No forest cover, wastelands or any other type of land use can be found anywhere in the mandal. Out of the entire land within the boundary, 88.03% of land (8647.80 Hectares) is used for agriculture and 2.87 % is covered by waterbodies. Rest of the land (9.1%) is used for rural settlements. This proves that the rural population is much more in this mandal when compared to the other mandals. Similar to the previous mandal small and large permanent ground watersheds are seen within the mandal area, but less in number. The latitudinal and longitudinal flow of perennial streams through the central region and availability of canals for irrigation in the western and eastern parts of the mandal are the reasons for less dependency on rain water for cropping. And hence, 98.58% of the total agricultural land is cropped in two seasons instead of rabi or kharif crops, which are dependent on rain or irrigation. Unlike the Bhatiprolu mandal, around 53 Hectares of land is classified as fallow. So here also land can be used to build storage houses or some other agro based industries, so that the socio-economic life pattern of the people can be improved of and some land can be transformed into other industrial or developmental use in future.

KOLLUR:

This is another adjacent mandal to the north of Bhatiprolu mandal in Guntur District having an area of 11798.60 Hectares (Table No. 2.22), where 77.54% of land (9148.13 Hectares) is used for agricultural purpose. 14.7% of the total land is covered by waterbodies (Fig-7). Other permanent and seasonal ground watersheds are seen in some places within the boundary. These provide proper water supply to the entire mandal. The perennial and non-perennial streams and river pass longitudinally through the eastern border of the mandal. Around 26% of the total agricultural land or 20% of the total mandal, spread longitudinally along the river, is mostly used for agricultural plantation. And rest of the 5955.17 Hectare land (50.47% of the mandal total) is cropped in two seasons. It is also found that the northern most river valley area is cropped in two seasons, may be because of the fertility of the soil. Quarries and industrial areas are seen located within the central region of the mandal. Although rural settlements are found throughout, the concentration is seen more or large, near the quarries and industrial areas of the central regions; possibly because of the opening of employment in nonagricultural activities and investment sectors. 7.68% of land is classified as rural built up area but no compact built up land use is seen. So here it can be suggested that, like the other two mandals, 98.3 Hectares of fallow land in this mandal, can be used for industrial growth or advanced government service providing centers. Forest and wasteland is completely absent in this mandal as well.

NAGARAM:

Nagaram mandal occupies 14323.23 Hectares of land in Guntur District (Table No. 2.23). 13305.73 Hectares of land (92.89%) in the mandal is used for agricultural purpose (Fig-7). Out of that 422.45 Hectares (2.94%) is covered by water and used for aquaculture. Probably this is the mandal where maximum area of land is used for agriculture. Perennial streams and canals are found within the eastern, central and southern parts of the mandals connecting those catchment areas used for aquaculture making a total of 4.72% land covered by waterbodies, out of which 2.94% is used for aquaculture. And because of this good irrigation facility more than 61.5% of land, spread from north-east to south-west, is cropped in two seasons. However, some places of the south-west and the entire southern part of the mandal are used for rain fed crops or kharif crops. This may be because these lands surround the watersheds used for aquaculture and are a little high land, probably the soil has less moisture containing capacity and is not adequately irrigated. Very little amount of land is used for rabi crops and agricultural plantation. Since most of the land is agricultural; so undoubtedly, rural settlements are scattered everywhere within the mandal, a total of 753.45 Hectares of land (5.26%) is used for rural settlements. Forest cover is completely absent here in the mandal. But some places are found to be wetlands, covered by mud or creeks. The 42 Hectares of fallow land can be used for building cold stores or food mixing mills for aquaculture or poultry food processing units. This will not only accelerate farming but also affect the economy of the people.

REPALLE:

Repalle mandal occupies 18631.62 Hectares of land in Guntur district (Table No. 2.24). Here 81.37% of land (15160.57 Hectare) is used for agriculture including 9.03% of surface water catchments (1683.5 Hectares) used for aquaculture. 2111.33 Hectares of land (11.33%) is covered by usable waterbodies (Fig-7) including the eastern most sectors with the non-perennial river flowing longitudinally along the border, the canal along the river and towards the central region and some small permanent or seasonal watersheds, excluding the water catchment areas used for aquaculture. These water catchments are mainly situated along the eastern river valley and south eastern ground watersheds that are connected to the waterbodies of Nagaram mandal. Apart from these 6215.496 Hectares of agricultural lands (33.36%), spread along the river valley and irrigated canal, are cropped in two seasons, because of the canal irrigation and presence of small permanent watersheds and more moisture containing capacity of the soil. But since the central, south-central and the western regions are not adequately irrigated and the water catchments are used mostly for aquaculture, these places are dependent more on monsoon water. So here kharif crops are cultivated. Very little amount of land is used for rabi crops. And because of increasing commercial farming of aquaculture, there is a concentration of population in compact built up settlement areas within the north-central region of the mandal that is surrounded by fallow agricultural land. Probably people are engaged more in commercial farming rather than industrial development or crop cultivation. Further these types of lands are seen along the watersheds used for aquaculture in the south-western and southern areas. There are possibilities of these fallow lands being transformed into high profitable aquaculture. Rural built up land is found everywhere within the mandal. The total built up or settlement area is a nearly 993 Hectares and 5.33% of the total mandal area. Small littoral forests are seen near the south-western aquaculture area.

VEMURU:

Vemuru is another high yielding mandal of Guntur District having an area of 10424.95 Hectares (Table No. 2.25). Most of the land of this mandal is used for agriculture. This covers an area of 9893.54 Hectares which is equal to nearly 95% of the total land (Fig-7). And the facility of a major canal dividing the mandal longitudinally along the western border region, is used for irrigation in the entire agricultural lands of the mandal. Availability of small permanent or seasonal ground watersheds is another reason which facilitates high yield from agricultural lands; hence 95% of agricultural land is cropped in two seasons. These places are mainly dependent on irrigation rather than rain water. So rabi or kharif cropping is hardly found anywhere in the mandal. A very small vegetated open area is seen within the central region of the mandal near to a rural built up area; which can be used for zaid farming by the villagers. Forest and wastelands are absent in the mandal. Rural settlements are found distinctively everywhere within the mandal. Because of the absence of mines, quarries or other industrial or commercial sectors, the mandal seems to be economically poor and the population and its density are also less.

GUNTUR DISTRICT
LAND USE/LAND COVER OF SELECTED MANDALS

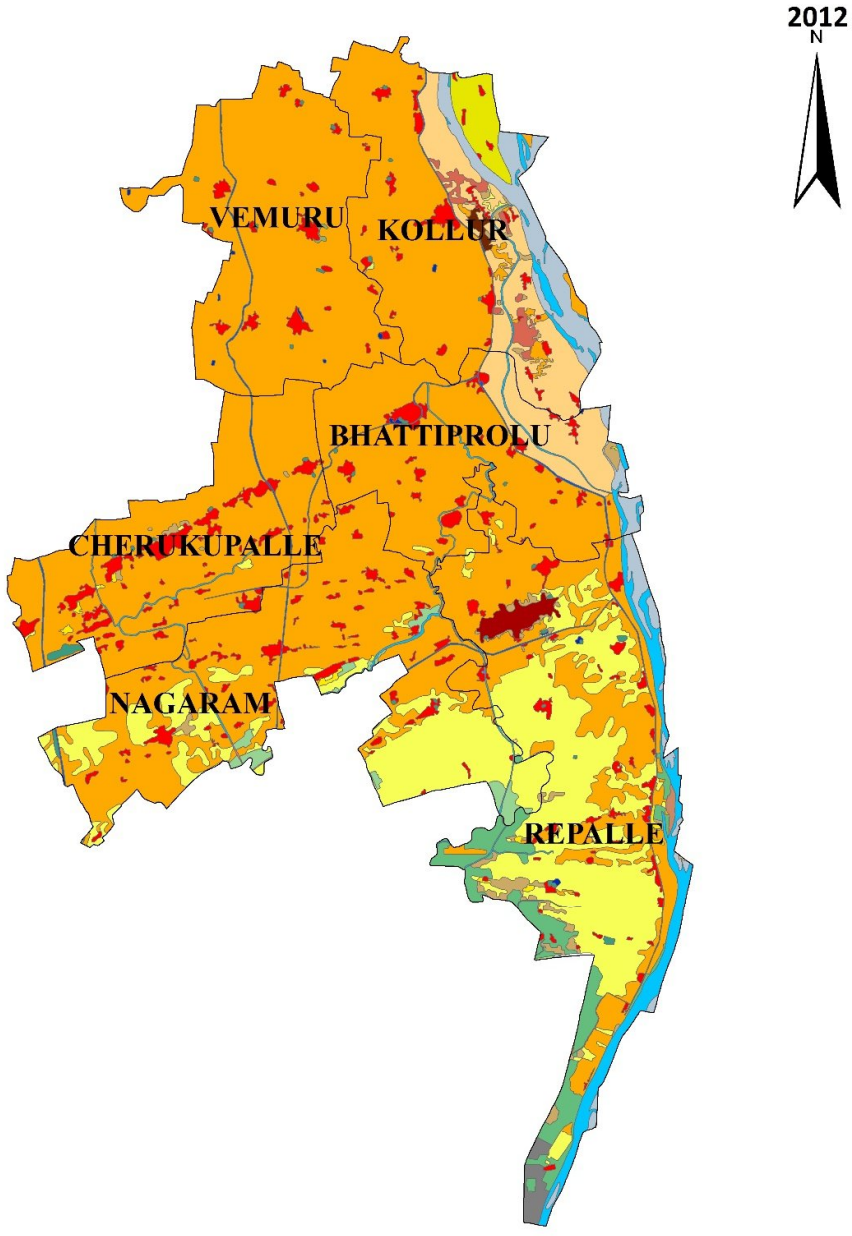


FIG- 7

Index – Bhatiprolu

- Agricultural Land-Crop Land-Cropped in 2 seasons
- Agricultural Land-Crop Land-Kharif Crop
- Agricultural Land-Crop Land-Rabi Crop
- Agricultural Land-Fallow
- Agricultural Land-Plantation
- Built Up (Rural)
- Waterbodies-Canal/Drain
- Waterbodies-Reservoir/Tanks-Permanent
- Waterbodies-Reservoir/Tanks-Seasonal
- Waterbodies-River/Stream-Non Perennial
- Waterbodies-River/Stream-Perennial

Index – Cherukupalle

- Agricultural Land-Crop Land-Cropped in 2 seasons
- Agricultural Land-Crop Land-Kharif Crop
- Agricultural Land-Crop Land-Rabi Crop
- Agricultural Land-Fallow
- Built Up (Rural)
- Waterbodies-Canal/Drain
- Waterbodies-Reservoir/Tanks-Permanent
- Waterbodies-River/Stream-Perennial

Index – Kollur

- Agricultural Land-Crop Land-Cropped more in 2 seasons
- Agricultural Land-Crop Land-Cropped in 2 seasons
- Agricultural Land-Crop Land-Kharif Crop
- Agricultural Land-Fallow
- Agricultural Land-Plantation
- Built Up (Rural)
- Built Up- Quarry
- Built Up-Industrial
- Vegetated / Open Area
- Waterbodies-Canal/Drain
- Waterbodies-Reservoir/Tanks-Permanent
- Waterbodies-Reservoir/Tanks-Seasonal
- Waterbodies-River/Stream-Non Perennial
- Waterbodies-River/Stream-Perennial

Index – Nagaram

- Agricultural Land-Aquaculture
- Agricultural Land-Crop Land-Cropped in 2 seasons
- Agricultural Land-Crop Land-Kharif Crop
- Agricultural Land-Crop Land-Rabi Crop
- Agricultural Land-Fallow
- Agricultural Land-Plantation
- Built Up (Rural)
- Waterbodies-Canal/Drain
- Waterbodies-Reservoir/Tanks-Permanent
- Waterbodies-River/Stream-Perennial
- Wetlands-Coastal - Lagoon, creeks, mud flats etc.

Table No. 2.20

Land Use/Land Cover of Bhatiprolu Mandal In Guntur District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	6920.431476	72.188197
2	Agricultural Land-Crop Land-Kharif Crop	25.71117126	0.268198
3	Agricultural Land-Crop Land-Rabi Crop	3.032483641	0.031632
4	Agricultural Land-Fallow	53.44080586	0.55745
5	Agricultural Land-Plantation	1515.452983	15.807948
6	Built Up	493.3223054	5.145929
7	Waterbodies	575.2611755	6.000648
Total Mandal		9586.7	100.00

Table No. 2.21

Land Use/Land Cover of Cherukupalle Mandal In Guntur District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	8525.56336	86.785672
2	Agricultural Land-Crop Land-Kharif Crop	34.41382961	0.350314
3	Agricultural Land-Crop Land-Rabi Crop	34.77304112	0.353971
4	Agricultural Land-Fallow	53.05242376	0.540045
5	Built Up	893.7310912	9.097704
6	Waterbodies	282.1654361	2.872293
Total Mandal		9823.7	100.00

Table No. 2.22

Land Use/Land Cover of Kollur Mandal In Guntur District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	6643.763647	56.309765
2	Agricultural Land-Crop Land-Kharif Crop	25.16526427	0.21329
3	Agricultural Land-Fallow	98.36533317	0.833703
4	Agricultural Land-Plantation	2380.835285	20.178965
5	Built Up	905.7455058	7.676721
6	Vegetated / Open Area	7.627657736	0.064649
7	Waterbodies	1737.096772	14.722906
Total Mandal		11798.6	100.00

Table No. 2.23

Land Use/Land Cover of Nagaram Mandal In Guntur District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Aquaculture	422.4505007	2.94941
2	Agricultural Land-Crop Land-Cropped in 2 seasons	8827.766465	61.632545
3	Agricultural Land-Crop Land-Kharif Crop	3980.77502	27.792454
4	Agricultural Land-Crop Land-Rabi Crop	30.84780667	0.215369
5	Agricultural Land-Fallow	42.79367069	0.298771
6	Agricultural Land-Plantation	1.09935102	0.007675
7	Built Up	753.4572993	5.26039
8	Waterbodies	253.8408872	1.772233
9	Wetlands-Coastal - Lagoon, creeks, mud flats etc.	10.19137382	0.071153
Total Mandal		14323.2	100.00

Table No. 2.24

Land Use/Land Cover of Repalle Mandal In Guntur District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Aquaculture	1683.481466	9.035613
2	Agricultural Land-Crop Land-Cropped in 2 seasons	6215.495656	33.359925
3	Agricultural Land-Crop Land-Kharif Crop	6729.949281	36.12111
4	Agricultural Land-Crop Land-Rabi Crop	58.26497105	0.312721
5	Agricultural Land-Fallow	467.4307718	2.508803
6	Agricultural Land-Plantation	5.945382126	0.03191
7	Built Up	992.9933716	5.329613
8	Forest	9.789776163	0.052544
9	Wastelands	57.86653456	0.310582
10	Waterbodies	2111.334567	11.331994
11	Wetlands	299.0720241	1.605185
Total Mandal		18631.6	100.00

Table No. 2.25

Land Use/Land Cover of Vemuru Mandal In Guntur District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	9893.557787	94.902693
2	Built Up	382.714511	3.67114
3	Vegetated / Open Area	18.63785333	0.178781
4	Waterbodies	130.0392684	1.247385
Total Mandal		10424.9	100.00

KRISHNA DISTRICT

CHALLAPALLE:

Challapalle mandal of Krishna District has occupied an area of 9375.93 hectares of land within the district (Table No. 2.26). The mandal is spread east-west, horizontally. 13.6% of the total mandal area (1275.27 Ha) is covered by waterbodies. Out of which Krishna River covers most of the region. Other small seasonal and permanent surface watersheds are found within the mandal. Two major canals, one passing along the Krishna River and another passing centrally towards east-west facilitate very good irrigation for the entire agricultural lands. As it can be seen in the fig-8, the river Krishna is the main source of water for this mandal. Because of assured source of water supply and high fertile soil within the river valley, some places here are cropped more than two seasons. Rest of the entire agricultural areas is found to be cropped in two seasons. This way around 6114.42 hectares of lands (65.21%) are cropped in two seasons. Although the mandal is rich in water resources still some of the places in the central and eastern regions are found to be kharif cropped. This occupies 898.29 hectares (9.58%) of the total area mandal. The possibility of these places being kharif cropped is that a large continuous land parcel is used for rural and industrial set up. So this might be obstructing the irrigation canals. And in the eastern part also along the canal some places are found to be used for aquaculture. There, cultivators might be earning more profit from aquaculture rather than crop cultivation. This may be the reason why more people have been attracted towards aquaculture instead of crop cultivation.Because of excessive of water content in the soil within the river valley, some commercial plantation is seen. Rural built up areas are scattered as usual. A total of 870.07 hectares of land or 9.28% of the total mandal area is used for industrial and rural settlements. This is very high in percentage when compared to the other mandals. Fallow lands are very less in measure. Forest coverage is found nowhere in the mandal and nowhere is the land wasted.

GHANTASALA:

This mandal is located to the north of Challapalle mandal sharing the common northern boundary, and is spread east-west, occupying an area of 11705.86 hectares of land in Krishna District (Table No. 2.27). Similar to Challapalle mandal, the Krishna River continues to flow, through the western border of the mandal (Fig-8). And the same canals also continue to flow within the mandal along with the river in the west and diagonally from the mid of north-west through the central region and to the south-east. Several small permanent and seasonal surface water catchments are scattered throughout the mandal. This rich source of water availability from the river and through irrigation network has allowed the cultivators to crop more in two seasons in some of the areas beside the river and the canals. This is practiced in 6.2% of the total land. Rest of the agricultural lands is seen cultivated in two seasons. This is around 69.5% of the total mandal area cropped in two seasons. Still a few of the places (9.7% of total area) are used for kharif cropping, although these are situated near the canals. Not much obstruction in irrigation is seen there off. But the possibility of these lands being kharif cropped, are there because the lands are less fertile or soil is hard. A very

small patch at the extreme east of the mandal is used for aquaculture, as wetland is located nearby. Only this wetland is remained unused. The entire wetland can be used for pisciculture or buffalo farming or can be used for jute or cane cropping. Even the land along the river and the canals can also be best reused by planting coconut trees. This way almost 85.61% of the total mandal area, that is 10022.20 hectares, is used for the purpose of agriculture. Forest cover is nowhere seen. Large parcels of rural built up areas have grown in the central part of the mandal, whereas other small patches of rural land use are found along the river bank and all other regions of it. A Sum total of 770.47 hectares of land (6.58%) is used for rural built ups. If the proposed commercial plantation nears the running waterbodies and the buffalo, pig or jute and cane farming could be made available in the mandal.

GUDURU:

Guduru mandal is one of the most significant mandals in Krishna District, being spread over an area of 12412.22 hectares (Table No. 2.28). The mandal is shaped as a rectangle placed longitudinally. Only 210.56 hectares of land (1.7%) is covered by waterbodies in this mandal, which seems to be very less when compared to the other mandals. A small perennial stream passes through the south-west part and another three canals pass through the central, eastern and northern regions of the mandal. A large permanent water reservoir is located in the western part along the canal. And fewer small seasonal watersheds are found in some places. Because of very good irrigation facility, the entire mandal has into high yielding agricultural land. It can be seen in the fig-8. that within the entire mandal almost 67.52% of the total land, that is 8380.88 hectares, are used for cropping in two seasons. Only the places along the eastern and southern border (2759.89 hectares or 22.24% of mandal total) are kharif cropped. This is because of the lack of irrigation facility. However, these places also can be used for multi cropping in a year if the irrigation could be extended. Some more lands are used for agricultural plantation in the north and north-eastern regions. These lands again can be used for mixed farming. Two or more small patches of lowlands near the wet lands are used for aquaculture. Wastelands are hardly seen anywhere in the mandal. Even forest is also absent. As the mandal is mainly based on agro cultivation, only rural built up areas are scattered here and there within the agro fields. Thus, 11583 hectares of land (93.32%) is used for agricultural purpose, whereas 611.4 hectares (4.93%) are for rural settlements. As much of the land is not wasted the best that can be suggested here is to change the land use practice. So that things can be modified or planned in future. For example; if coconut trees can be planted along the waterbodies and the drainage network, then the growth of oil industries or coconut jute reprocessing units can be expected within the mandal.

MACHILIPATANAM:

This mandal is spread over a large extent of geographical area in the district of Krishna. The total area of the mandal is 40712.78 hectares (Table No. 2.29). This is why mixed or variety of land use and land cover is found over here. 11.41% of the total mandal is covered by forest composed of open and dense or artificial forests. Since the eastern border is coastal, so the forest found along it is usually littoral and endowed with water swamps. These types of forests cannot be used for any kind of

productive purpose. It just has a positive impact on the environment or the biomass. These are found within the northern and along the eastern and southern coastal regions. Again 31.34% of the total land (12760.27 hectares) is wetlands. These natural wetlands are seen along the eastern coastal belt surrounding the littoral forest areas and northern coast. Also, manmade wetlands are seen strewn within the north, south-central and the southern border of the riverbank. Most of these lands are saltpans. These lands by nature are low and infertile. Because of the advantage of being located near the coast, these basins are used for salt harvesting. So, the lands have become somewhat productive. Some more places spread along the coast are clayey or muddy. So these lands are absolutely unusable and unproductive. The entire eastern border is coastal sandy area. The best that can be done is recreation in lagoons or seashore tourist places etc…. Even saline aquaculture or salt harvesting can also be undertaken here. Thus 12760.27 hectares of land that makes 31.34% of the total land is not used for cropping purpose, but in some other profitable ways. Since the mandal is a coastal area, the soils would be mostly salt affected and also availability of fresh water would be less when compared to the other mandals. Only 1143.44 hectares of land is occupied by waterbodies which is only 2.8% of the total mandal area. Perennial rivers and streams flow along the north, central east and south border region. Three more canals are seen flowing longitudinally within the northern region and horizontally through the central region of the mandal. Amongst these only the canal flowing in the north part is used for agriculture purpose. The two canals in the central area are used to supply fresh water to the aquaculture belt as it runs through the saltpan areas. Seasonal and permanent ground watersheds are hardly found here. These are the main reasons for why only 18531.3 hectares of land (45.52%) is available for agriculture purpose. Also, out of this 4377.25 hectares (10.75%) are utilized for aquaculture which is mostly surrounded by manmade wetlands. Excluding these three major type of land use or land cover, namely aquaculture, forest cover and wetlands, the amount of land that could successfully be used for cropping is only 34.77% of the total mandal area. Within these croplands close to the waterbodies some of the places (2176.34 Ha, 5.34%) are cropped in two seasons and almost 9545.6 hectares of lands are still rain dependent. So those 23.44% of lands are kharif cropped. About 1748.43 hectares of land (4.3%) are found to be fallow and only 1.6% land is used for agricultural plantation. Most of these agro fields are found within the western region of the mandal from north to south. This is all because of more forest cover, most of the available lands are wetlands or saltpans or used for aquaculture. There is an improper distribution of irrigated fresh water to the agricultural fields. Even for that the available agro fields have become less productive. And 586.74 hectares (1.44%) lands are still found to be wastelands. Because of aquaculture, which is a highly profitable business and salt cultivation practice and also because of less land available for residential establishment, a very large parcel of compact settlement area has developed in the central region of the mandal. All other small rural settlements are dispersed here and there. The total lands used in this context are3044.3 Ha or 7.48% of the total mandal area. To improve the productivity and to meet the optimum utility of the available lands, the extension of irrigation network to the crop fields is required. The wastelands and unproductive fallow lands can be used for installing salt reprocessing units, aquatic food cold stores, aquatic food reprocessing units and wind

farms etc… Not much developmental plan can be proposed as the available land is very less although the mandal is very large in size.

MOVVA:

Movva is a very small mandal of Krishna District having an area of 14248.12 hectares (Table No. 2.30). The fig-8. itself depicts that most of it is agricultural land. Forest cover is completely absent. No waste or other unproductive or lands are identified within the mandal. Land covered by waterbodies is also less. Only 240.42 hectares (1.69%) of land is covered by waterbodies, which includes a perennial stream crossing the mandal from north-west to south-east and three other small canals running within the eastern, western and extreme north part of the mandal. Other small permanent and seasonal ground watersheds are found here and there. The seasonal watersheds are most probably village ponds found within the rural settlement areas. Although the availability of irrigated water as a whole is not sufficient in the mandal some of the western part of the agricultural lands (694.23 Ha or 4.87%) are cropped in two seasons. Widely spread throughout the mandal around 6911.6 hectares (48.5%) of the lands are cropped in two seasons.These are seen in the north-east, south-east, east, south-west and some places of north-western part of the mandal. Rest of the central region spread diagonally from north-west to south-east along the perennial stream lack irrigation and hence are kharif cropped. 5608.10 hectares or 39.36% of the total mandal area kharif cropped. If these central regions could be irrigated then there is a possibility of these places being used for rabi crops. A very small industrial patch is located near the perennial stream to the north part of the mandal. Rural settlements are located throughout the mandal. 793.77 hectares of land are measured to be used for rural and industrial settlements that make 5.57% of the total mandal area.

KRISHNA DISTRICT
LAND USE/LAND COVER OF SELECTED MANDALS

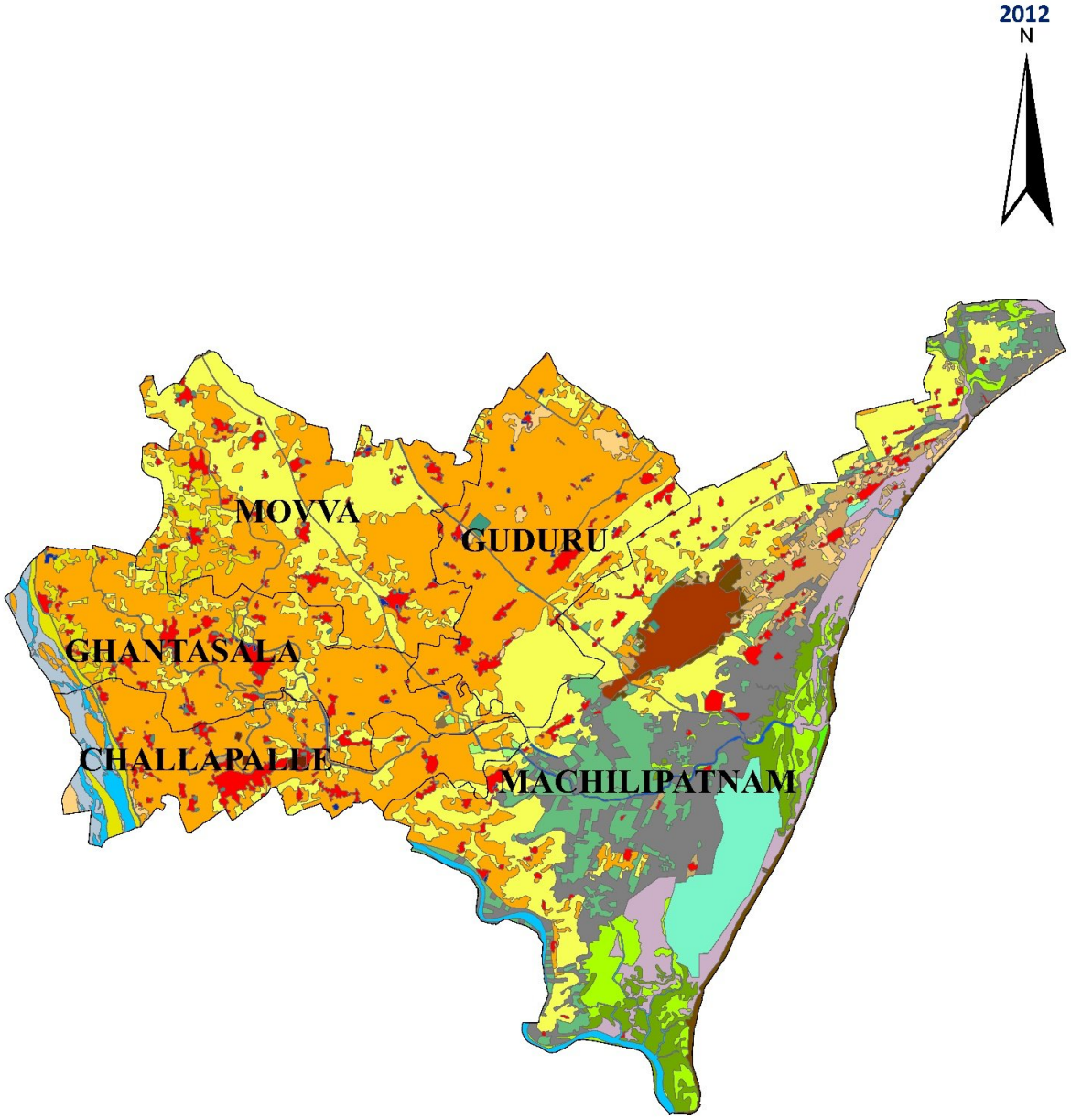


FIG - 8

Index – Challapalle

Index – Ghantasala

Index – Guduru

Index – Machilipatanam

Index – Movva

Table No. 2.26

Land Use/Land Cover of Challapalle Mandal In Krishna District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Aquaculture	61.82759248	0.659429
2	Agricultural Land-Crop Land-Cropped in 2 seasons	6114.422914	65.214065
3	Agricultural Land-Crop Land-Kharif Crop	898.2920231	9.580835
4	Agricultural Land-Fallow	18.25873383	0.194741
5	Agricultural Land-Plantation	137.780506	1.469513
6	Built Up	870.0732802	9.279864
7	Waterbodies	1275.27162	13.601553
Total Mandal		9375.9	100.00

Table No. 2.27

Land Use/Land Cover of Ghantasala Mandal In Krishna District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Aquaculture	23.86719929	0.203891
2	Agricultural Land-Crop Land-Cropped in 2 seasons	8865.419734	75.734909
3	Agricultural Land-Crop Land-Kharif Crop	1132.916762	9.678205
4	Built Up	770.4741247	6.581954
5	Waterbodies	891.4642889	7.615541
6	Wetlands	21.71425289	0.185499
Total Mandal		11705.9	100.00

Table No. 2.28

Land Use/Land Cover of Guduru Mandal In Krishna District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Aquaculture	33.04002402	0.266189
2	Agricultural Land-Crop Land-Cropped in 2 seasons	8380.88147	67.521212
3	Agricultural Land-Crop Land-Kharif Crop	2759.886067	22.235233
4	Agricultural Land-Fallow	4.662541014	0.037564
5	Agricultural Land-Plantation	404.5347545	3.259165
6	Built Up	611.3984423	4.925778
7	Waterbodies	210.5591495	1.696385
8	Wetlands	7.257599708	0.058471
Total Mandal		12412.2	100.00

Table No. 2.29

Land Use/Land Cover of Machilipatanam Mandal In Krishna District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Aquaculture	4377.2514	10.751537
2	Agricultural Land-Crop Land-Cropped in 2 seasons	2176.3455	5.345606
3	Agricultural Land-Crop Land-Kharif Crop	9545.6020	23.446196
4	Agricultural Land-Fallow	1748.4332	4.294554
5	Agricultural Land-Plantation	683.6736	1.67926
6	Built Up	3044.3098	7.477526
7	Forest	4646.7065	11.413381
8	Wastelands	586.7425	1.441175
9	Waterbodies	1143.4481	2.808572
10	Wetlands	12760.2711	31.342164
Total Mandal		40712.8	100.00

Table No. 2.30

Land Use/Land Cover of Movva Mandal In Krishna District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	7605.84	53.381323
2	Agricultural Land-Crop Land-Kharif Crop	5608.10	39.360261
3	Built Up	793.77	5.57104
4	Waterbodies	240.42	1.687377
Total Mandal		14248.1	100.00

ANANTHAPUR DISTRICT

NARPALA:

Narpala mandal is located in Ananthapur District and spreads over a land-area of 26,369.7 hectares of this total area approximately 65.38% is used for agriculture (i.e. nearly 17,240 hectares) (Table No. 2.31). 28.36% of the total mandal area is cropped in two seasons. Predominantly the central and some parts of the northern region of the mandal are used for cultivation because of the availability of rich water resources like reservoirs, tanks, canals, drains or streams passing through the crop-lands. The water resources pass through the north-east; north-west to the south-central region. These descriptions are identified within the fig-9A.The waterbodies and drainage systems cover a total area of 588.39 hectares of land occupying 2.23% of the total mandal area. Few places of the north-central region, most parts of the eastern, western and southern regions of the mandal, are Kharif cultivated areas, which cover almost 7147 hectares of land accounting to 27.1%of the total mandal area. These regions are not so rich in water resources and so people mainly depend on the monsoon for cultivation. So, rain fed or kharif crops are cultivated in these areas. Even these areas can be cropped in two seasons if stationary water can be made available or the existing canals can be extended. But rabi crops are hardly found within the mandal. Fallow agricultural lands are also seen in the southern region and few places of the central, eastern and northern regions of the mandal. 2081 hectares of land is unused, although it is classified as agricultural land. This implies that there is less production of crops and these unused lands cover 7.89% of the mandal. Only around (1-2) % of the total land is used for agricultural production of the 65.38% of the total land used for agricultural purpose, 2557.49 hectares of land is covered by forest, placed at extreme north and south part of the mandal and a very small area from the extreme south-eastern region of the mandal. This occupies 9.7% of the total mandal area. The wastelands are found scattered in between the eastern and southern kharif crop lands and some northern regions of the mandals. These are either rocky/stony, salt affected or scrub covered lands and 5503.38hectare of land that is equal to 20.87% of the total mandal area. These are unsuitable for cropping activities. However, mills or other agro based small scale industries can be made available there for agro-industrial development purpose, as two-third of the mandal is well cropped and only one-fifth is area of the mandal is wasteland. Considering the demography of the mandal, it is very clearly seen in the fig-9A. that the mandal is agriculturally rich and poor in industrial sector. So, most of the population found in the mandal depend on agriculture. The total rural built up area of the mandal is about 480.42 hectares that is 1.82% of the total mandal area. If the suggested reuse of the wastelands could be taken forward, then in future there might be the possibility of rise in population concentration in some places, wherever the industrial development is undertaken and also the compact built up, industrial and a better transport network, GDP and improved life pattern with more feasibility to the public or private sector services, could also be expected.

PUTLUR:

Putlur is another mandal, adjacent to the Narpala mandal of Ananthapur District, sharing the north-east boundary. The total area of the mandal is 34603.14 hectare (Table No. 2.32). 23569.25 hectare (68.11%) of the total land is used for cropping

(Fig-9A). These are mostly the north-east, east and longitudinally spread north-west to south-east, passing through the central region and some places of the south-west part of the mandal. Permanent as well as seasonal source of stationary waterbodies are seen within the north-eastern forest belt, central and south-central region of the mandal. Canals are stretched towards north, south-east and the north-eastern regions, along which people crop in two seasons. 5479.29hectare of land (15.83%) of the total mandal area is used in this way. Only 1303.65hectares (3.77%) of land is kharif cultivated. But almost 13965.97hectares of land (40.36%) is used for rabi crops, because moister containing capacity of the soil and very good irrigation facilities. Fallow lands are also seen in the north, central, north-east, south and some places of the south-east and south-west regions. But these do not occupy much area, only a small portion of 1414.70hectares of land that is equal to 4.09% of the total mandal. But it also matters because these places, fall under the agricultural land use category, but are unproductive. These areas are to be focussed more and need well planned irrigation and re-fertilization for being reused for cropping purpose. Very similar to the fallow lands, almost 4% land of the total mandal is used for plantation. But 4599.55hectare land (13.29%) of the total area is covered by forest, that is spread from north-west to south. 5672.53hectare of lands are wastelands. So,16.39% of the total mandal is used for rabi crops and some places of the south-western border of the mandal. Again, this is unproductive. So, these places need to be developed either for industrial or residential purpose to the Narpala mandal. Rural built up areas are scattered within these cultivated lands. Overall, 70% land of the total land is used for Agricultural purpose, out of which 4% is unproductive and 16% of the total land is completely unused. These need a keen attention and need to be reutilized. Bio-chemical fertilizer production units, seed processing or agro-industries can be constructed for better yield in the future. This could better the socio-economic life of the people of the mandal, and can affect the demography, population density and net immigration within the mandal. The result could be expected to be positive if the theories of economic development can be applied here.

TALUPULA:

This mandal occupies a space of 45373.2hectares of land within Ananthapur District (Table No. 2.33). Around 18404hectare land, covering 41% of the total mandal is used for agriculture (Fig-9B). It seems to be quite small when compared to the two mandals of the district mentioned earlier. This is because, more than 38% of the mandal is covered by forest and about 19% land is waste land 57% land is completely unproductive and another 11.5% land became follow, although classified as agricultural, land. The forest has covered the northern and north-eastern border, central portion of the north-west, complete south-west and southern border of the mandal. Wastelands are scattered within the forest and throughout the mandal from north-west to south-east mixed with the croplands. Although the mandal has rich water resource 8 most of the rivers or streams run through the wastelands. Canals are very less and the lands used for agriculture are not well irrigated. This justifies the increase of fallow lands. Further most of the cultivated lands are found dependent on ground water (Reservoirs or tanks, either permanent or seasonal). As these stable watersheds and catchments are comparatively less distributed throughout the mandal from north-west to south-east, only 8.22% of land is used for cultivation in two

seasons. But seasonal water catchment areas are better distributed within the region; so, 8393.93hectare lands (nearly 19%) are used for rain fed cultivation. Permanent reservoirs or tanks are also seen and, rabi crops are cultivated in some places because these crops are irrigation dependent. These crops do not wait for the monsoon. Agricultural and industrial development affects the distribution and density of population. Meagre cultivated area and lack of industrial infrastructure indicate poor development of the mandal. So, although rural built up areas are seen within the agricultural region it is very less (0.59%) when compared to the total area of the mandal total. For the best use of the land and its development, extension of canal irrigation to the fallow lands and re-fertilization, utilization of the wastelands for commercial plantation and forest industries, identification of mineral resources from the forest or quarries and also leasing the open forest areas for Pastoral Nomads or Sheep Husbandry etc…is advisable for this mandal.

YADIKI:

Yadiki is another significant mandal of Ananthapur District, with an area of 34305.55 hectares (Table No. 2.34). 21037.95 hectares of land (61.33%) of the total mandal area is classified as agricultural land out of which 3718.47 hectares (10.84%) cultivated in two seasons. These lands are scattered in small patches throughout the mandal except the extreme eastern part. This is because of the well distributed seasonal watersheds, canal irrigation facilities and the fertility of the soil. Waterbodies cover more than 2% of the total mandal area, which shows that the land is rich in water resources and the presence of non-perennial or seasonal small rivulets/streams can be considered the land surrounding these running waterbodies can be used for cultivating rabi crops. It can be seen clearly in the fig-9C. that most of the rabi cropped areas (nearly 34%, 11525hectares) are surrounded by these seasonal running waterbodies flowing through the central to the south-eastern region of the mandal. The monsoon fed crops or kharif crop cultivation is also practised in the north-western, southern and some eastern parts of the mandal.The Kharif crop cultivation is less and is done only in 2074.83 hectares which is 6.03% of the total mandal area. This may be because the rainfall gets regulated by forests and there is more precipitation. So the cultivation of kharif crops are seen near the northern and southern forest covered areas (4335.16 hectare or 12.64% of the total land). Although the mandal is rich in water resources, still about 3442.56 hectares of agricultural land is found to be fallow. This covers only 10.03% of the total mandal area. These places are seen in the southern, eastern, central and some of the eastern parts as well. Even though the places are situated just along the water bodies they are unproductive. This may be because, the soil is less fertile or more and more people have been engaged in other earning practices *like. Mining or working in, industrial or quarries.* The map depicts the presence of quarries, active mining areas and industrial areas in different places of the mandal. This attracts the skilled and unskilled workers to the employment sector and causes the rise in population. Compact and sparse built up areas are seen within the central part of the mandal and because of farming activities and other less paid employments, rural built up areas are found dispersed over the entire mandal. More than 931 hectares of land (2.71%) is found to be built up area. This might be another cause of the rise of wastelands within the mandal nearly 7280.85 hectares or 21.22% of the total mandal. Out of this most of the lands are scrub lands and salt affected lands and a few places

are stony or rocky lands. These are seen in the southern, north-western, north-eastern, central and eastern parts of the mandal. So, almost 15058.57 hectares of land (nearly 44%) has become non-productive because of forests, wastelands and agricultural fallow lands. Here it can be suggested that the best use of the land can be made by using, the salt affected lands for industrial development, the scrub lands and open forests could be used for animal husbandry, the fallow lands should be used for commercial crops, with the extension of irrigation facilities, which later can be converted for industrial development within the mandal.

ANANTHAPUR DISTRICT
LAND USE/LAND COVER OF SELECTED MANDALS

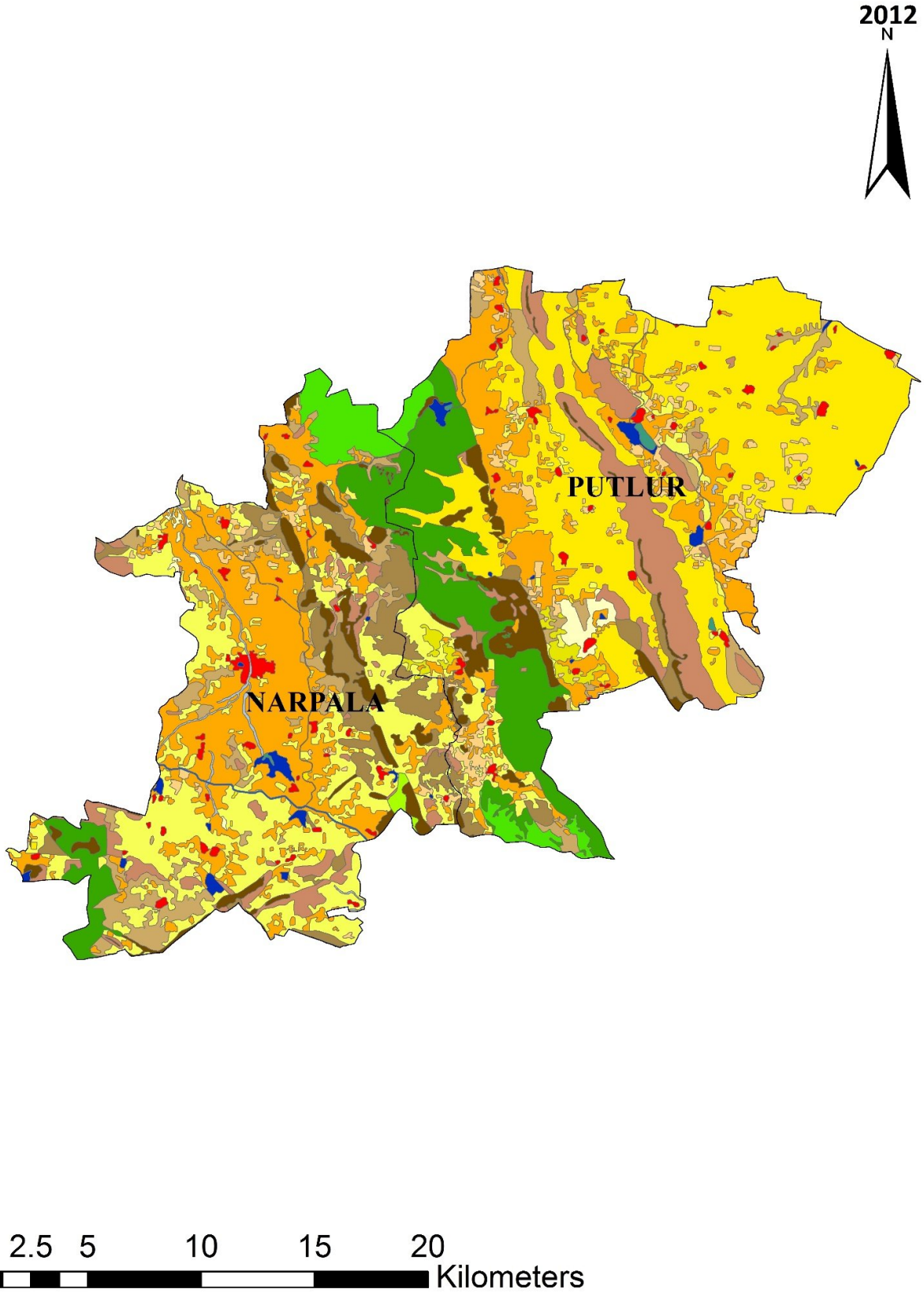


FIG- 9 (A)

ANANTHAPUR DISTRICT
LAND USE/LAND COVER OF SELECTED MANDAL

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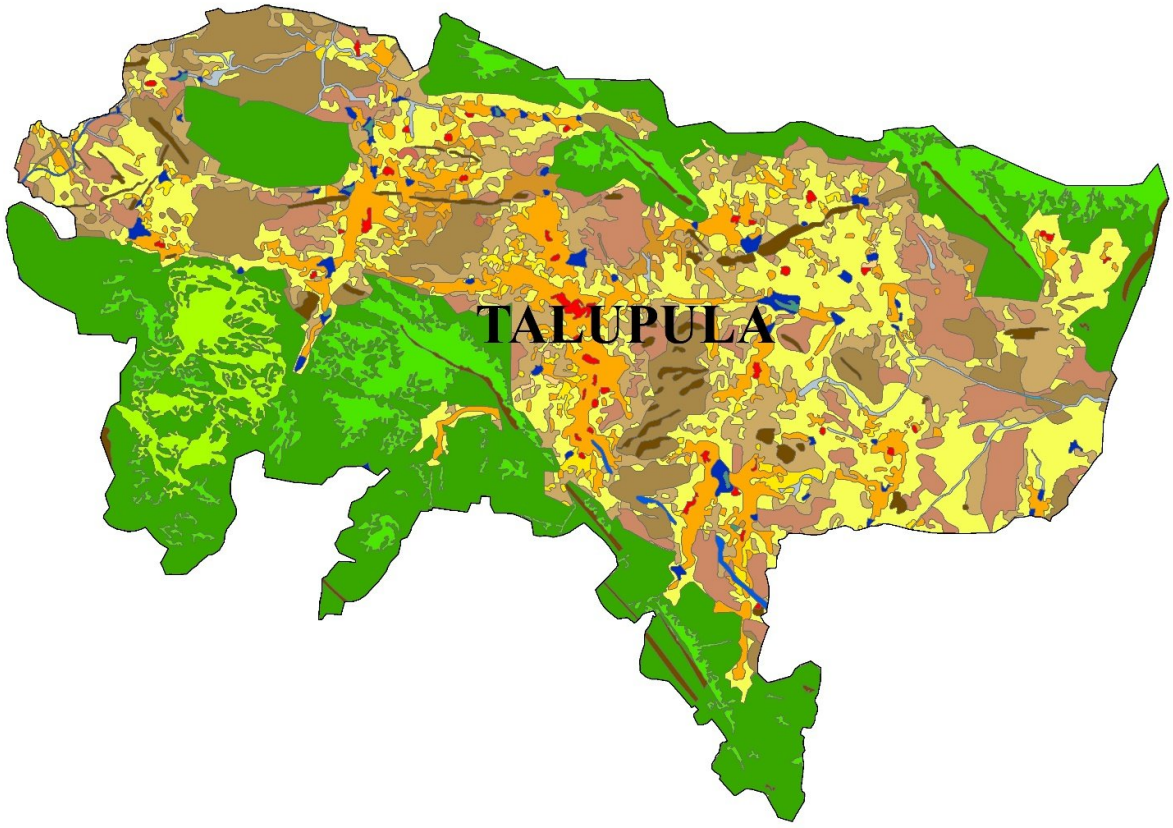


0 2.25 4.5 9 13.5 18

Kilometers

FIG- 9 (B)

ANANTHAPUR DISTRICT
LAND USE/LAND COVER OF SELECTED MANDAL

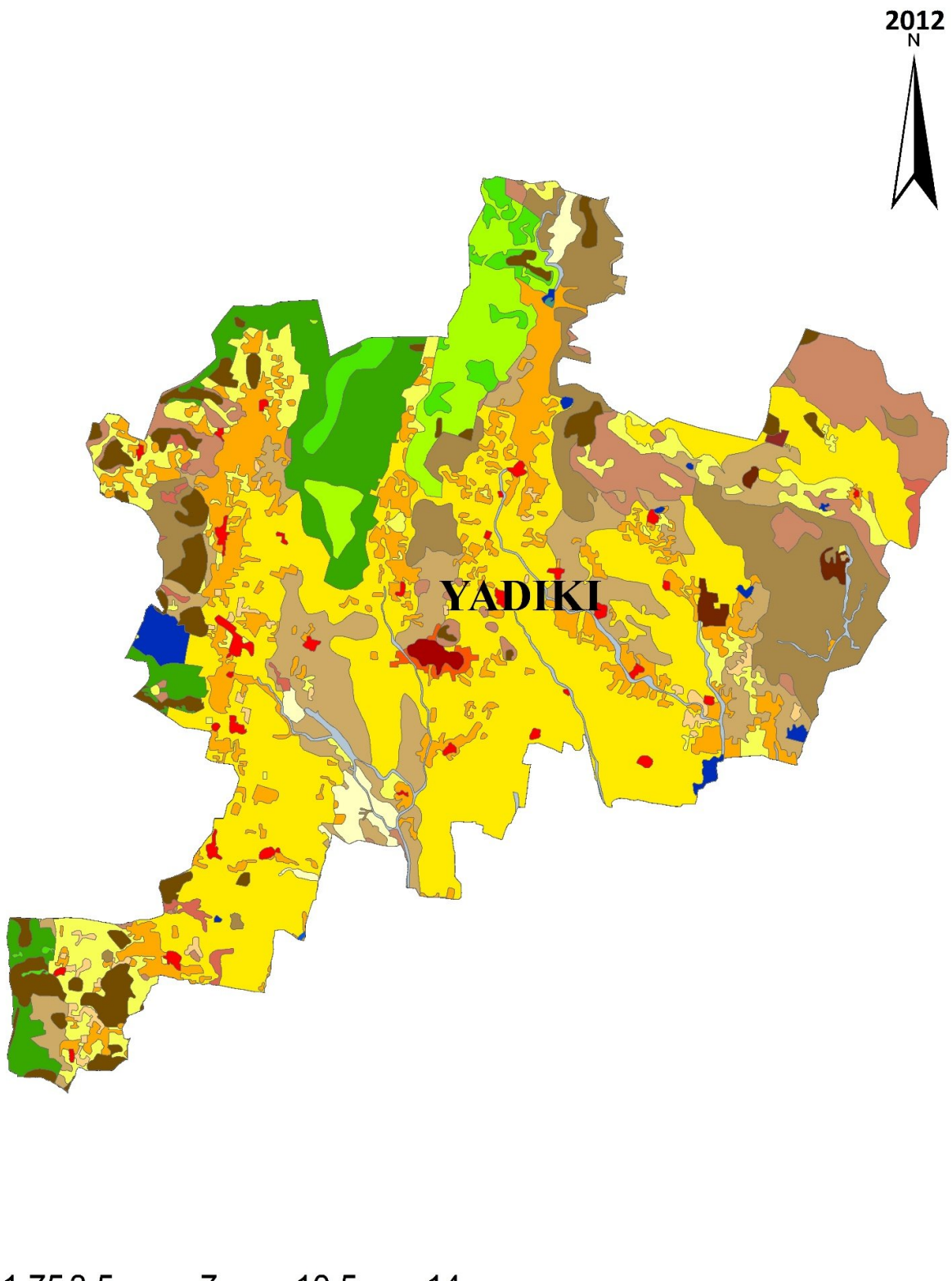
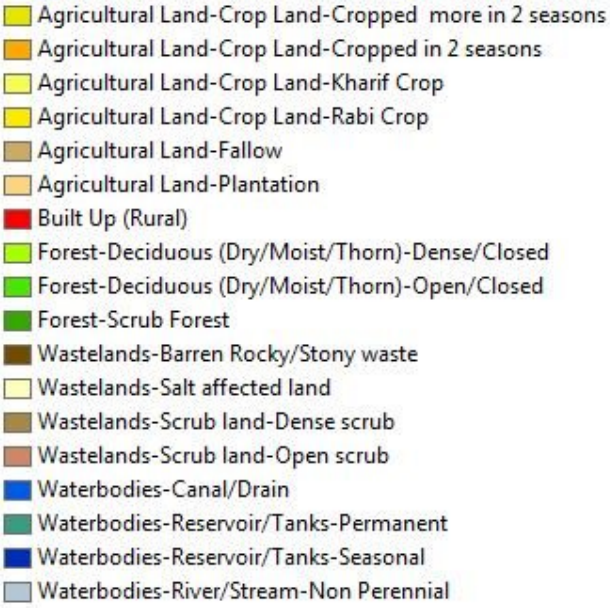


FIG- 9 (C)

Index- Narpala

Index- Putlur



Index- Talupula

Index – Yadiki

Table No. 2.31

Land Use/Land Cover of Narpala Mandal In Ananthapur District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	7479.5	28.36
2	Agricultural Land-Crop Land-Kharif Crop	7147.2	27.10
3	Agricultural Land-Crop Land-Rabi Crop	42.6	0.16
4	Agricultural Land-Fallow	2081.0	7.89
5	Agricultural Land-Plantation	489.6	1.86
6	Built Up (Rural)	480.4	1.82
7	Forest	2557.5	9.70
8	Wastelands	5503.4	20.87
9	Waterbodies	588.4	2.23
Total Mandal		26369.7	100.00

Table No. 2.32

Land Use/Land Cover of Putlur Mandal In Ananthapur District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	5479.294652	15.834676
2	Agricultural Land-Crop Land-Kharif Crop	1303.646017	3.767421
3	Agricultural Land-Crop Land-Rabi Crop	13965.96857	40.360412
4	Agricultural Land-Fallow	1414.698731	4.088354
5	Agricultural Land-Plantation	1405.644115	4.062187
6	Built Up (Rural)	398.6874567	1.152171
7	Forest	4599.550147	13.292293
8	Wastelands	5672.525033	16.393095
9	Waterbodies	363.1223296	1.049391
Total Mandal		34603.1	100.00

Table No. 2.33

Land Use/Land Cover of Talupula Mandal In Ananthapur District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	3727.41303	8.215004
2	Agricultural Land-Crop Land-Kharif Crop	8393.930139	18.499739
3	Agricultural Land-Crop Land-Rabi Crop	589.4105373	1.299027
4	Agricultural Land-Crop Land-Zaid Crop	423.1823556	0.93267
5	Agricultural Land-Fallow	5215.247829	11.494106
6	Agricultural Land-Plantation	55.17353361	0.121599
7	Built Up	266.263361	0.586829
8	Forest	17367.02402	38.275923
9	Wastelands	8423.818372	18.565611
10	Waterbodies	911.7712036	2.009492
Total Mandal		45373.2	100.00

Table No. 2.34

Land Use/Land Cover of Yadiki Mandal In Ananthapur District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	3718.467728	10.839259
2	Agricultural Land-Crop Land-Kharif Crop	2074.828715	6.048084
3	Agricultural Land-Crop Land-Rabi Crop	11525.97034	33.597973
4	Agricultural Land-Fallow	3442.559542	10.034992
5	Agricultural Land-Plantation	276.1227639	0.804892
6	Built Up	931.0301659	2.713935
7	Forest	4335.16094	12.636908
8	Tree Clad Area-Dense/Closed	0.000666955	0.000002
9	Wastelands	7280.853527	21.223543
10	Waterbodies	720.5584374	2.100414
Total Mandal		34305.6	100.00

KURNOOL DISTRICT

ADONI:

Adoni mandal has good potential for agriculture. It is located towards the western part of Kurnool district. The area under agricultural land (cropped in two seasons) accounts to 16.38% (Table No. 2.35). The agricultural land fallow occupies about 53.32% Fig-10A. It may be due to fluctuations in rainfall conditions and the farmers might not have gone for cultivation. Most of cultivation has been carried out during the rabi season which accounted for 6.16% of the total Geographic area. The built-up area covers about 4.00% of the Geographic area and the major part of the area is in the centre of the mandal and is surrounded by wastelands. Barren, rocky and stony waste. These wastelands occupy almost 12.97% of the total Geographic area of the district. Adoni mandal is dominated by agricultural activities, there is very low percentage of area under forests which accounts to a meagre 1.92% of the total Geographic area and occur towards the northern part of the mandal. These forests are mostly deciduous forests. Water bodies were seen scattered in the centre of the mandal. River/stream appear in light blue to dark blue tone towards the western part of the mandal which is agriculturally predominant. The predominant crops grown in this mandal are rice, cotton and groundnut.

KALLUR:

Kallur mandal is located in the central part of Kurnool district. It occupies an area of about 327020 hectares (Table No. 2.36) agriculture dominates this mandal and covers about 75% of the total Geographic to 5% of the total Geographic area fig-10C. River/stream appears in the middle of the accord mandal dividing the mandal into two parts. The Southern eastern part of the mandal is occupied by forests and vegetative area which accounts to 6.55% of the total Geographic area. The built-up area is scattered all over the mandal accounting to 6.75%. The continuous built up area is located towards the northern eastern part of the mandal. The wastelands account for 6.40% of the total area. The major crops of the mandal are rice and ground nut and most of these crops were grown under assured and irrigated water supply.

MAHANANDI:

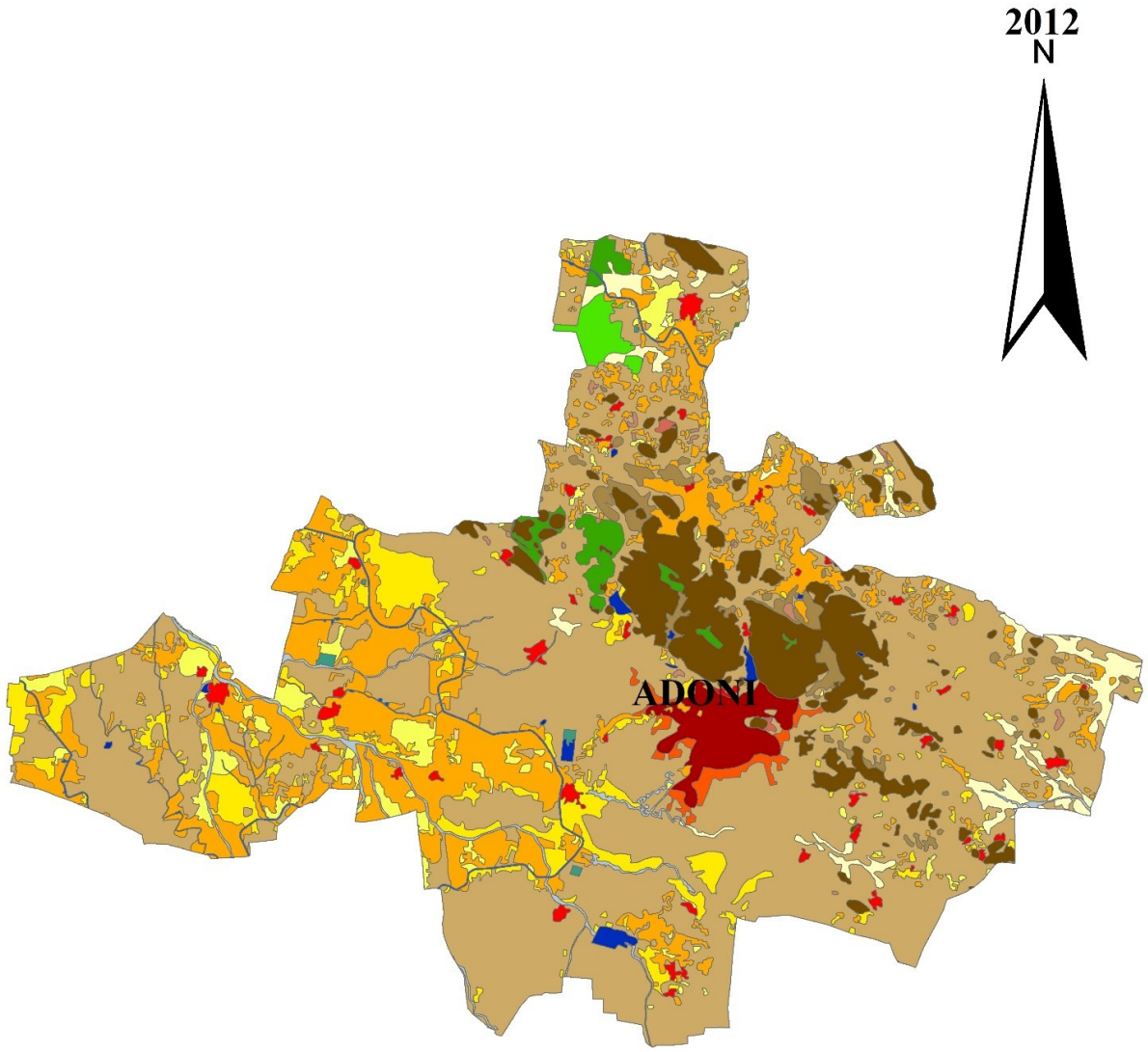
Mahanandi mandal is located towards the eastern part of the Kurnool district. This mandal predominantly has both forest and agricultural lands fig-10B. The western part of the mandal is completely covered by forests which are the extension of the Eastern Ghats. The forest lands occupy almost about 61% of the Total Geographic area (Table No. 2.37). This forest comprises of deciduous species and the trees shed their leaves once in a year. The western part is completely covered by agricultural lands which accounts to 30% of the total Geographic area which is under two cropped area. The built upland occupies about 1.11% of the total Geographic area and is scattered only in the western part of the mandal. Water bodies such as river/streams, lakes and tanks occupy about 3.22% of the total area and are seen mostly in the western part of the mandal. The chief crops grown in this mandal are rice & ground nut.

VELDURTHI:

Veldurthi mandal is also located in the central part of Kurnool district and towards south of Kallur mandal. This mandal too has good cultivable land and accounts to 62.8% of the total Geographic area fig-10C. Chief crops grown in this mandal are rice and ground nut. Wastelands occupy about 17.67% of the total Geographic area (Table No. 2.38) and they are mostly spread out in the northern western part of the mandal. Areas under forests occupy 14.29% and seen located in northern and eastern part of the mandal accounting to 14.29%. The built-up area, which is scattered all over the mandal, accounts to meagre 2.53% of the total geographical area. Water bodies such as tanks/lakes appear in light blue to blue tone accounting to 2.72% and are located in the central and south western part of the mandal.

KURNOOL DISTRICT

LAND USE/LAND COVER OF SELECTED MANDAL



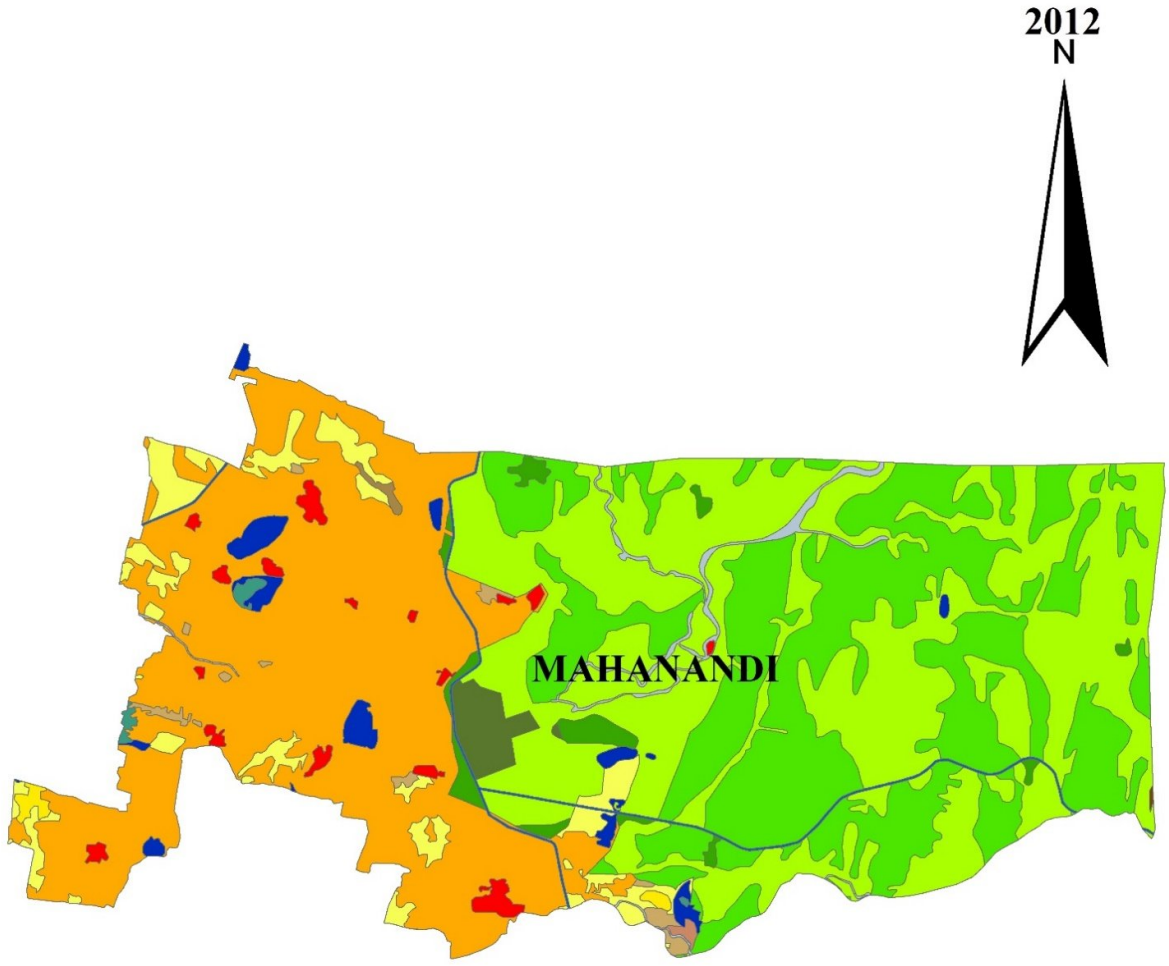
0 2 4 8 12 16

Kilometers

FIG- 10 (A)

KURNOOL DISTRICT

LAND USE/LAND COVER OF SELECTED MANDAL



0 1.25 2.5 5 7.5 10

Kilometers

FIG- 10 (B)

KURNOOL DISTRICT

LAND USE/LAND COVER OF SELECTED MANDAL

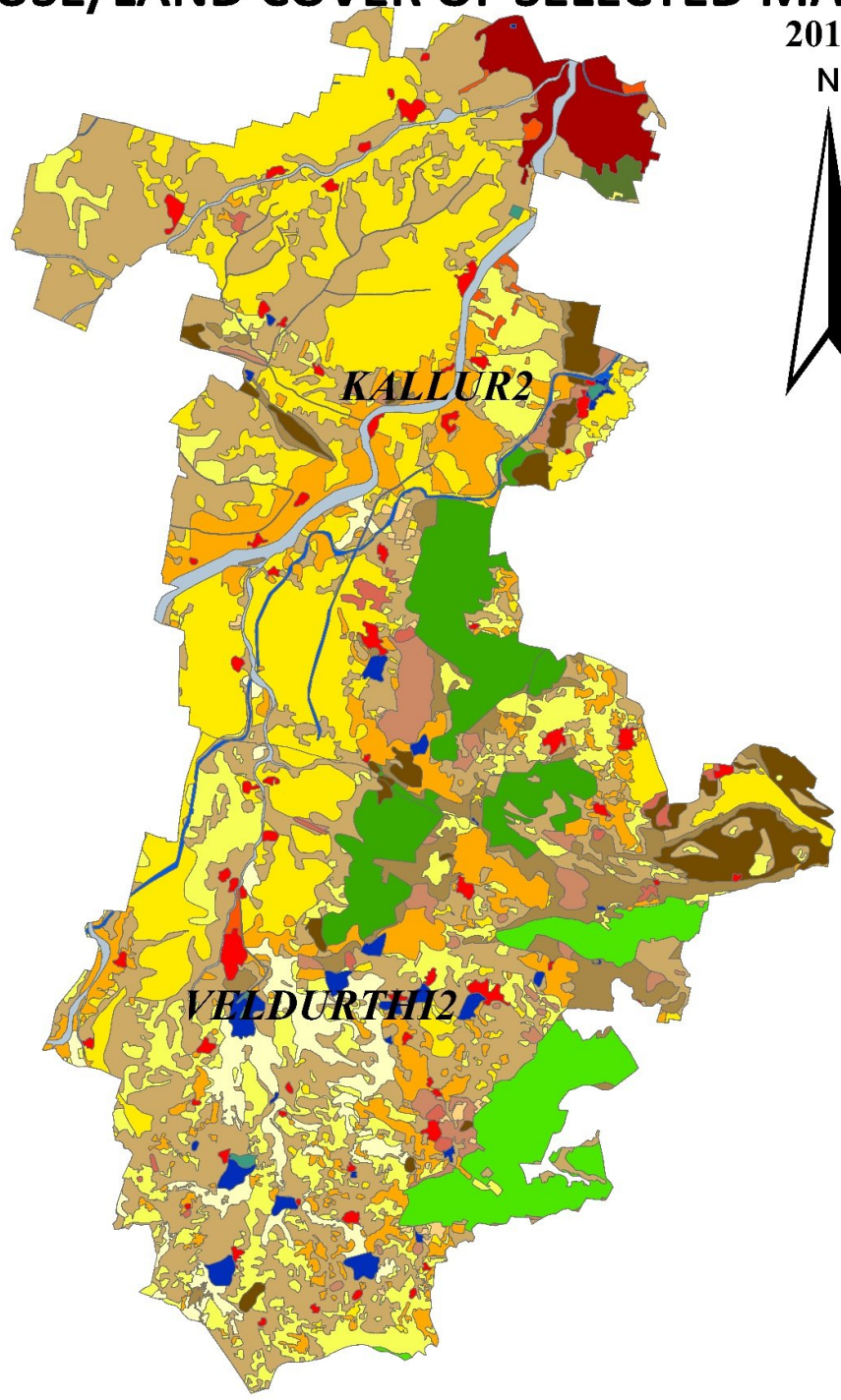
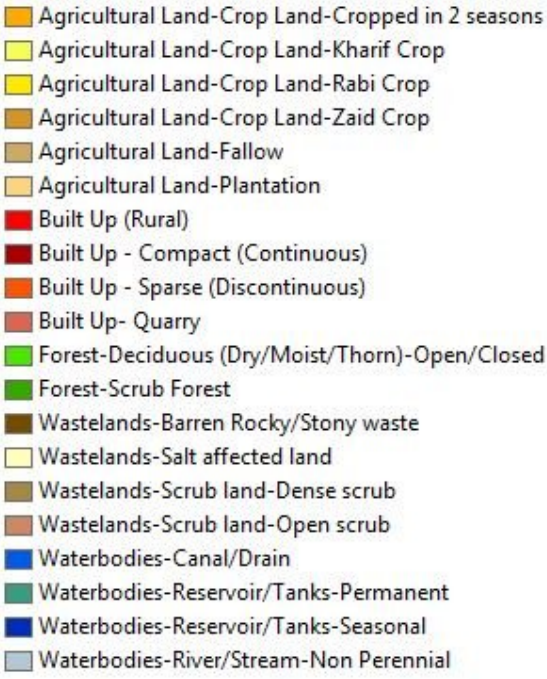


FIG- 10 (C)

Index – Adoni



Index – Kallur2

Index – Mahanandi

Index – Veldurthi2

Table No. 2.35

Land Use/Land Cover of Adoni Mandal In Kurnool District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	9142.38	16.38
2	Agricultural Land-Crop Land-Kharif Crop	1666.77	2.99
3	Agricultural Land-Crop Land-Rabi Crop	3439.99	6.16
4	Agricultural Land-Crop Land-Zaid Crop	2.94	0.01
5	Agricultural Land-Fallow	29769.38	53.32
6	Agricultural Land-Plantation	6.34	0.01
7	Built Up	2233.42	4.00
8	Forest	1074.29	1.92
9	Wastelands	7242.51	12.97
10	Waterbodies	1246.70	2.23
Total Mandal		55824.7	100.00

Table No. 2.36

Land Use/Land Cover of Kallur Mandal In Kurnool District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	2941.37	8.99
2	Agricultural Land-Crop Land-Kharif Crop	1901.76	5.81
3	Agricultural Land-Crop Land-Rabi Crop	10204.47	31.19
4	Agricultural Land-Fallow	9502.08	29.04
5	Agricultural Land-Plantation	77.05	0.24
6	Built Up	2209.32	6.75
7	Forest	1961.01	5.99
8	Vegetated / Open Area	182.13	0.56
9	Wastelands	2093.23	6.40
10	Waterbodies	1648.16	5.04
Total Mandal		32720.6	100.00

Table No. 2.37

Land Use/Land Cover of Mahanandi Mandal In Kurnool District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	8348.62	29.95
2	Agricultural Land-Crop Land-Kharif Crop	1120.76	4.02
3	Agricultural Land-Crop Land-Rabi Crop	74.86	0.27
4	Agricultural Land-Fallow	148.45	0.53
5	Built Up	308.22	1.11
6	Forest	16916.94	60.69
7	Wastelands	61.63	0.22
8	Waterbodies	896.34	3.22
Total Mandal		27875.8	100.00

Table No. 2.38

Land Use/Land Cover of Veldurthy Mandal In Kurnool District			
Sl. No.	**Categories**	**Feature Area in Hectares**	**Percentage With Respect to Mandal Total**
1	Agricultural Land-Crop Land-Cropped in 2 seasons	3131.65	9.11
2	Agricultural Land-Crop Land-Kharif Crop	5298.80	15.42
3	Agricultural Land-Crop Land-Rabi Crop	3325.31	9.68
4	Agricultural Land-Fallow	9735.09	28.32
5	Agricultural Land-Plantation	91.51	0.27
6	Built Up	869.17	2.53
7	Forest	4911.65	14.29
8	Wastelands	6071.60	17.67
9	Waterbodies	935.20	2.72
Total Mandal		34370.0	100.00

CHAPTER-III
CLIMATIC DYNAMICS

CLIMATIC DYNAMICS

The greenhouse gas which increases atmospheric temperature has concentrated in excess in the environment because of unrestrained exploitation of fossil fuels.It is already quite evident that human activities of various levels have been affected adversely because of excessive concentration of atmospheric carbon dioxide. Environmentalists, social activities, scientists are deeply concerned over the damages that are occurring on agriculture, forestry and other ecosystems from drastic climatic changes which in turn would affect trading policies both at the national and international levels as also resource use and food security.The crop yields reduce considerably when the temperature increases.Similarly, if there is heavy rainfall the growing period of certain crops get unduly delayed, while considering the effect of climate change on agricultural productivity is dependent on weather.Most of the Indian states depend on rainfall for irrigating the crops and this is applicable to the Andhra Pradesh state as well.As mentioned earlier, the region's economy will be greatly affected if there is a fall in agricultural productivity due to negative climatic changes.A shift in the timings of rainfall also affects the cropping pattern of the region.

The methodology used in this study is to analyze the various meteorological parameters and its effect on agricultural productivity at the mandal and district level.The study is conducted for 25 years and an analysis of the agricultural and meteorological data is carried out.Computation of statistical data related to the average monthly, seasonal and annual rainfall is done using the SPSS & Microsoft Excel 2007 software for each mandal of the district.In order to detect any persistence in the rainfall series a linear regression test was done.

The two meteorological parameters of rainfall and temperature are used for analysis in the selected districts, as far as temperature and rainfall is concerned data was collected for a period beginning 1988 to 2012.In this chapter an analysis was carried out on the district level rainfall data for the selected districts, gathered between the periods 1988 to 2012.

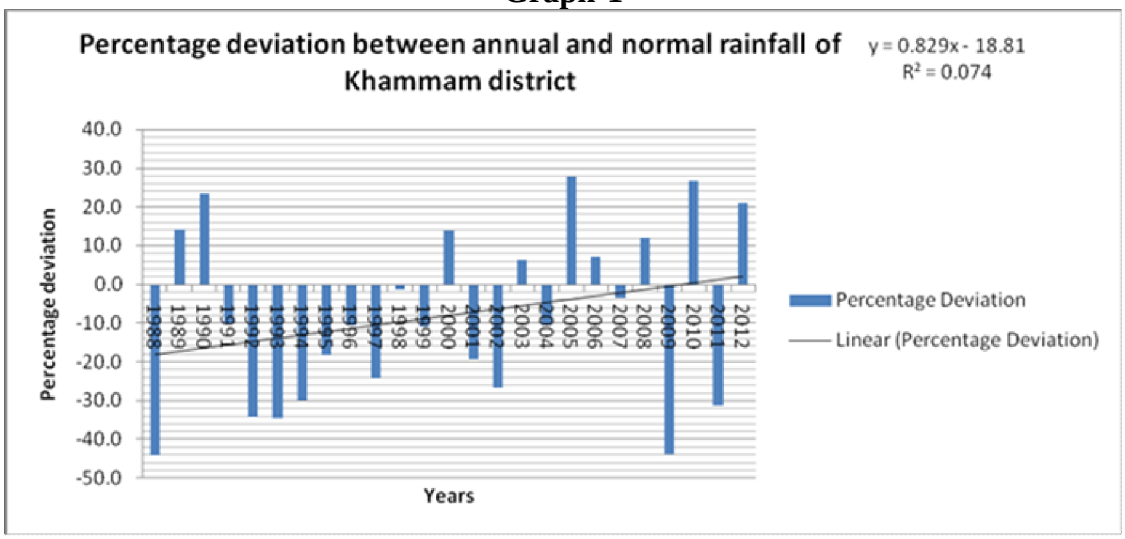
TELANGANA REGION

Four districts from the two agro climatic zones of Telangana region were taken for this study. The four districts such as Nalgonda and Mahabubnagar from Southern Telangana zone and Khammam and Warangal districts from central Telangana zone were studied in detail.

KHAMMAM DISTRICT

This district falls under the central Telangana Agro climatic zone. The analysis of the season wise break up shows that the rainfall has predominantly occurred in the south west monsoon season. The district has an annual rainfall ranging between 900 to 1500 mm.

Graph-1



The graph-1 shows the percentage deviation between the annual and normal rainfall of the district from 1988 to 2012. The graph shows vast deviation during the year 2008-2009 with-48% deviation indicating the rainfall. Out of the 25 years (ie.1988-2012), the district received excess rainfall for only 9 years. The excess rainfall received during 2005 and 2010 showing 29% deviation from normal rainfall. The district almost experienced drought prone conditions for 15 years.

Correlation between the temperature (average minimum and maximum) and rainfall during both seasons (Southwest and Northeast monsoon season) is shown in the following table-3.1

Table-3.1: Correlation between the Temperature and Rainfall during Southwest and Northeast Monsoon in Khammam District

Seasons	Average Maximum Temperature	Average Minimum Temperature
Southwest Monsoon	-0.24529	0.099523

Northeast Monsoon	-0.23495	0.296115

The correlation analysis shows negative relationship between maximum temperatures during both monsoon seasons.It indicates that as the temperature increases the rainfall decreased in the district.

Out of the 25 years, about 15 years have recorded rainfall below the normal during Southwest monsoon season and around 17 years the rainfall received was below normal during the Northeast monsoon season. The following table-3.2 highlights about this fact.

Table-3.2: Months with actual average rainfall below its normal rainfall (mm) in Khammam District for a period between 1988-2012

Months	Number of Years below normal rainfall	Range of Percentage Deviation from normal rainfall for deficit years (below normal)	Normal Rain fall
June	15	-72.8 to -1.5	131.8
July	20	-62.5 to -0.1	314.5
August	13	-67.6 to -7.1	279.5
September	14	-67.1 to -1.3	164.5
SWM	**15.5**	**-44.21 to -3.05**	**222.57**
October	15	-76.4 to -9.4	105.9
November	16	-98.8 to -29.6	21.3
December	19	-100 to -34.8	3.1
NEM	**16.66**	**-78.02 to -4.81**	**43.43**

Fig-11A shows the distribution of seasonal rainfall during the southwest monsoon for all the mandals of the district. Very high and high average rainfall received was seen towards the North eastern side of the district. The mandals are Wazeed, Venkatapuram, Cherla, Manugur, Burgampahad, Chintur, Ramachandrapuram and Kunavaram, all these mandals belonging to high attitude zone. The central part of the district had moderate amount of rainfall. The south western part of the district received low to very low average rainfall.

The *Fig*-11B shows the 25 years average northeast monsoon rainfall. Very high rainfall during this season was received by Aswarraopet, Pammapeta, Sathupalli, Khammam, Enkur, Bonakal, Chintakani, Mudigonda, Nelkondapalli, Thirumalayapalem. Moderate amount of rainfall was received in the central part of the district. Low and very low rainfall zone was seen in the North and Northeastern part of the district.

The *Fig*-11C shows the average percentage deviation of rainfall. Very high and percentage deviation was found in the mandals of Khammam (R), Konjeri, Wyra and Pinapaka. Moderate percentage deviation was found in Cherla, Dummagudem, Aswapuram, Velair, Vemsoor, Bayyaram and Nallur mandals. Remaining mandals showed low to very low percentage deviation.

KHAMMAM DISTRICT

AVERAGE SOUTHWESTMONSOON RAINFALL

1988-2012

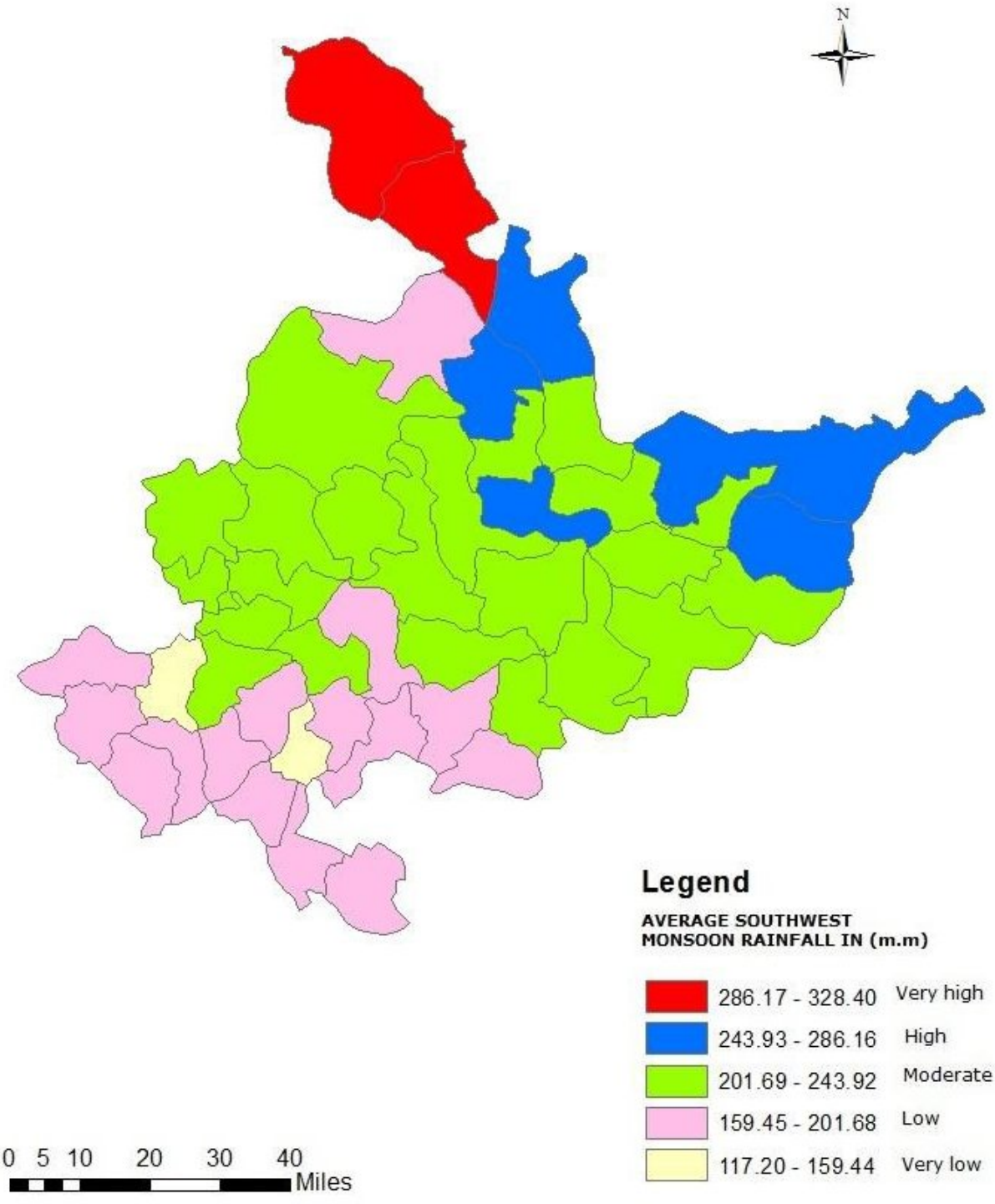
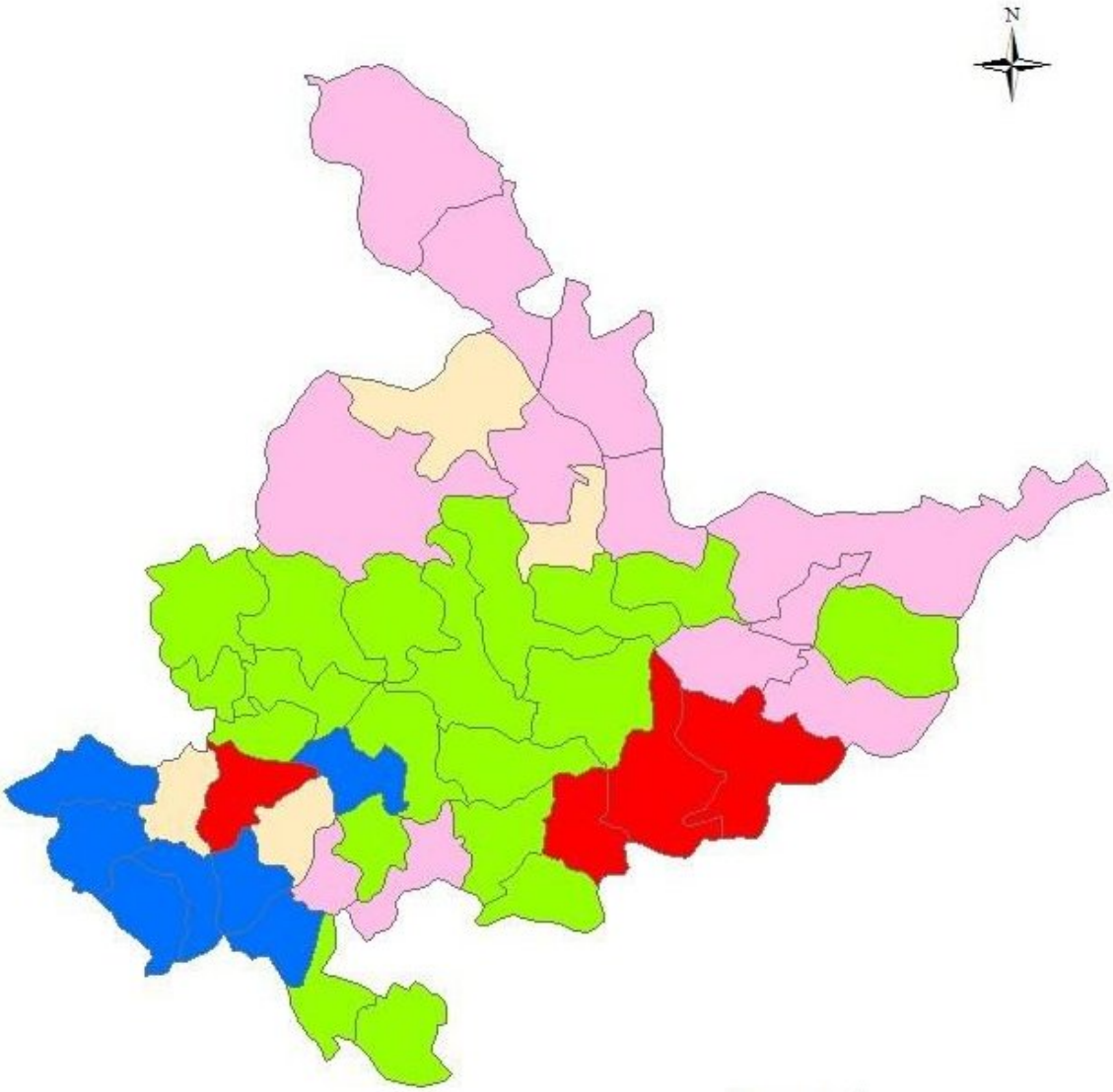


FIG-11 (A)

KHAMMAM DISTRICT

AVERAGE NORTHEAST MONSOON RAINFALL

1988-2012



Legend

AVERAGE NORTHEAST MONSOON RAINFALL IN (m.m)

53.03 - 60.00	Very high
46.05 - 53.02	High
39.07 - 46.04	Moderate
32.09 - 39.06	Low
25.10 - 32.08	Very low

0 5 10 20 30 40 Miles

FIG-11 (B)

KHAMMAM DISTRICT

AVERAGE PERCENTAGE DEVIATION OF RAINFALL

1988-2012

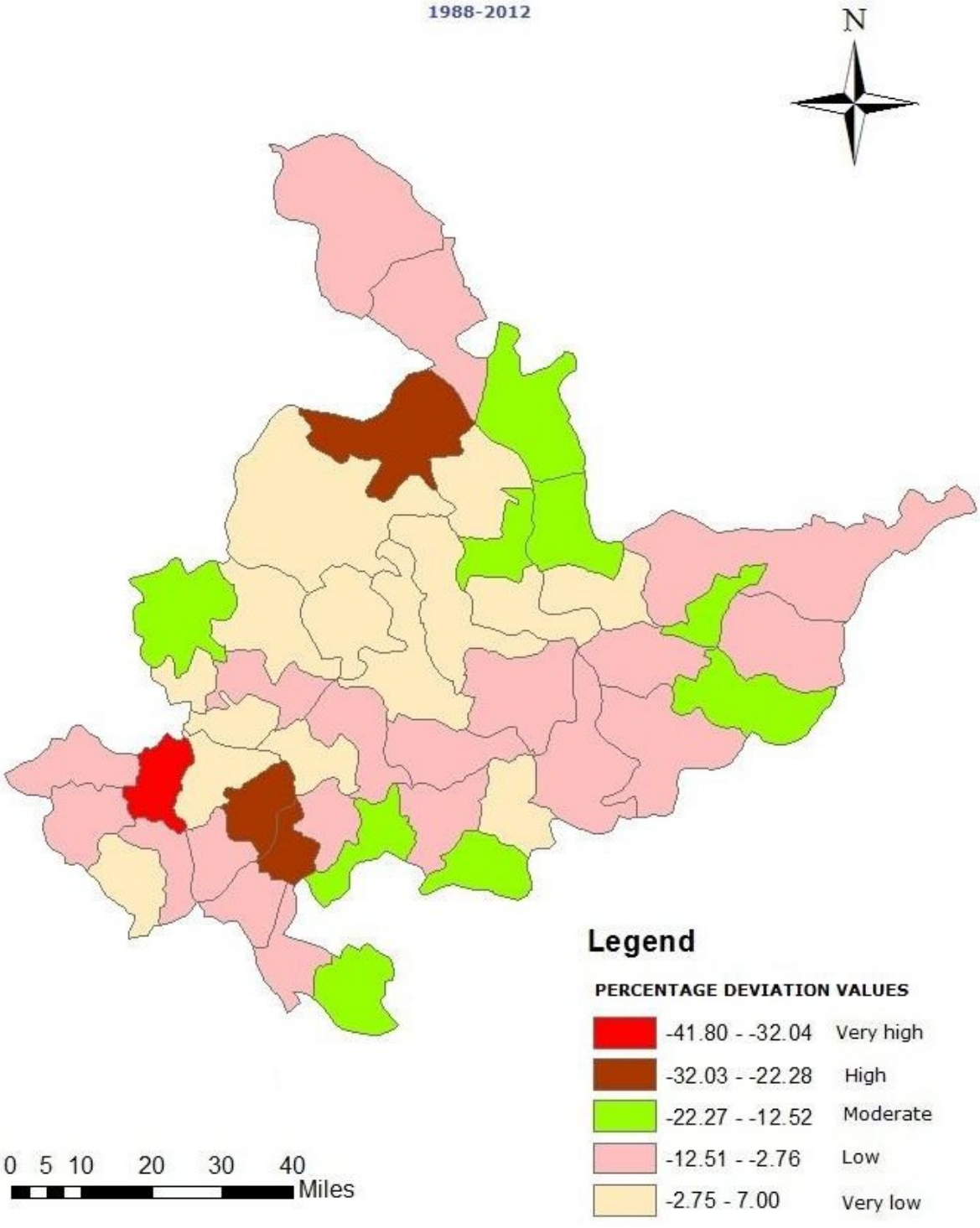
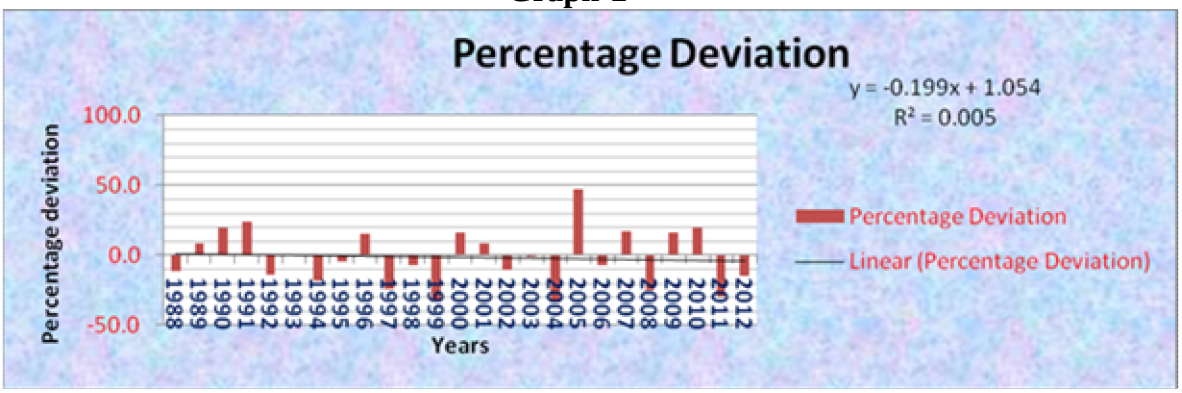


FIG-11 (C)

MAHBUBNAGAR DISTRICT

This district also falls under the southern Telangana Agroclimatic zone and has an annual rainfall ranging between 700-900 mm. A detailed analysis of the temperature data shows erratic variations of the data in the maximum average temperature during the first half of the decade and moving towards increasing trends form 2005 on words.

Graph-2



The Graph-2 shows the percentage deviation between the annual and normal rainfall of the district from 1988 to 2012. There is a large deviation in the amount of rainfall recorded in the year 2005, where it exceeds normal rainfall showing 48.0 percentage deviations. Where as in the year 2004 the rainfall received was less than normal rainfall showing -35.0 percentage deviations. The linear trend shows a decrease in the percentage deviation of Rainfall.

Table-3.3: Correlation between the Temperature and Rainfall during Southwest and Northeast Monsoon in Mahabubnagar District

Seasons	Average Maximum Temperature	Average Minimum Temperature
Southwest Monsoon	-0.15767	0.080663
Northeast Monsoon	0.271626	0.254787

From the temperature data of 25 years it is observed that the maximum temperature of the district was in the months of April and May.A correlation analysis between the temperature and rainfall during Southwest and Northeast monsoon was done. During the Southwest monsoon season, the trend has shown a negative correlation(-0.157) indicating that as the temperature increases the rainfall decreases.This is shown in the above table-3.3

Table-3.4: Months with actual average rainfall below its normal rainfall (mm) in Mahbubnagar District for a period between 1988-2012

Months	Number of Years below normal rainfall	Range of Percentage Deviation from normal rainfall for deficit years (below normal)	Normal Rain fall
June	14	-78.9 to -5.9	71.2
July	19	-76.5 to -6.7	146.5
August	9	-75.0 to -10.2	121
September	13	-86.4 to -6.8	107.9
SWM	**13.75**	**-48.51 to -2.82**	**111.65**
October	15	-95.2 to -6.5	90.3
November	19	-100 to -3	25.6
December	20	-100 to -84	5
NEM	**18**	**-94.24 to -5.39**	**40.3**

The rainfall distribution over a period of 25 years is shown in the table-3.4 out of these 25 years the district received below normal rainfall for fourteen years during Southwest monsoon season and 18 years below normal rainfall during Northeast monsoon season.The range of percentage deviation from normal rainfall for deficit years is given in the above table.

The district receives most of the rainfall during Southwest monsoon *Fig*-12A shows the distribution of seasonal rainfall during the south west monsoon for the mandals of Mahbubnagar district during 1988-2012. Very high rainfall was recorded in the mandals of Kodangal, Doulatabad and Mahabubnagar. High rainfall was recorded in the mandals of Kodangal, Atmakur, Wanaparthy, Kalwakurthy, Farooqnagar. Very low rainfall was recorded in Ieeja, Maldaka, Ghatt, Dharur, Mangoor, Bombaspet, Vangoor and Tadoor mandals. Remaining mandals showed moderate to low average rainfall.

Fig-12B showsthe average Northeast monsoon rainfall for the period 1998-2012. Very high and high rainfall was recorded in Amrabad, Veldanda and Kalwakurthy mandals. Moderate and low average rainfall during the Northeast monsoon was seen in almost all the mandals of the district. Very low rainfall was seen in the mandals of Bombaspet, Ghatt, Bhootpur and Ghanpura.

Further an analysis of Average Percentage Deviation of rainfall depicted in the *Fig*-12C shows very high and high percentage deviation of rainfall was recorded in the southeast and central and north-western parts of the district. Almost 50 percentage of the district shows vast percentage deviation of rainfall. The northeast mandals and the southern mandals of the district showed low to very low percentage deviation of rainfall.

MAHABUBNAGAR DISTRICT

AVERAGE SOUTHWEST MONSOON RAINFALL

1988-2012

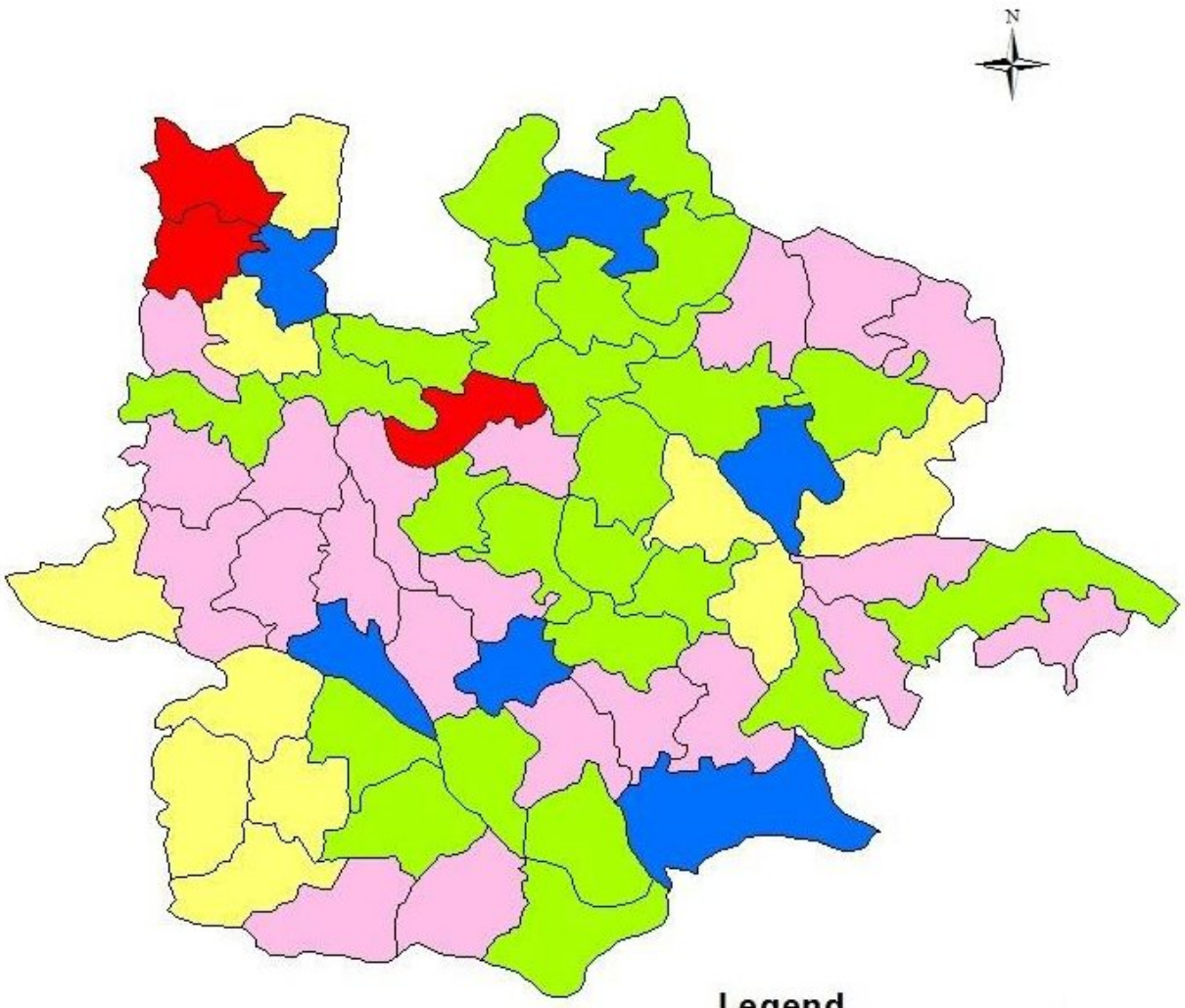


FIG-12 (A)

MAHABUBNAGAR DISTRICT

AVERAGE NORTHEAST MONSOON RAINFALL

1988-2012

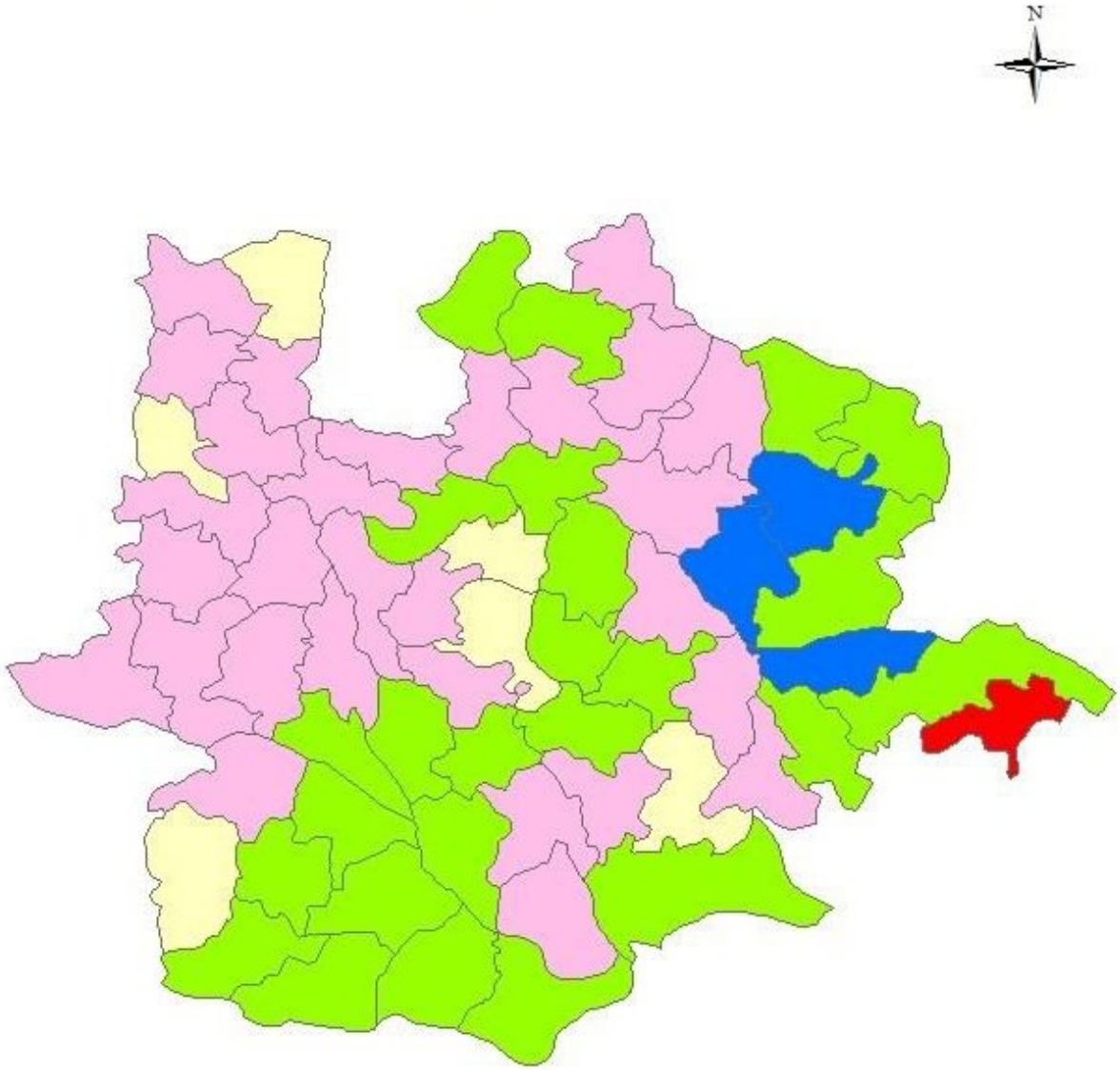


FIG-12 (B)

MAHABUBNAGAR DISTRICT

AVERAGE PERCENTAGE DEVIATION OF RAINFALL

1988-2012

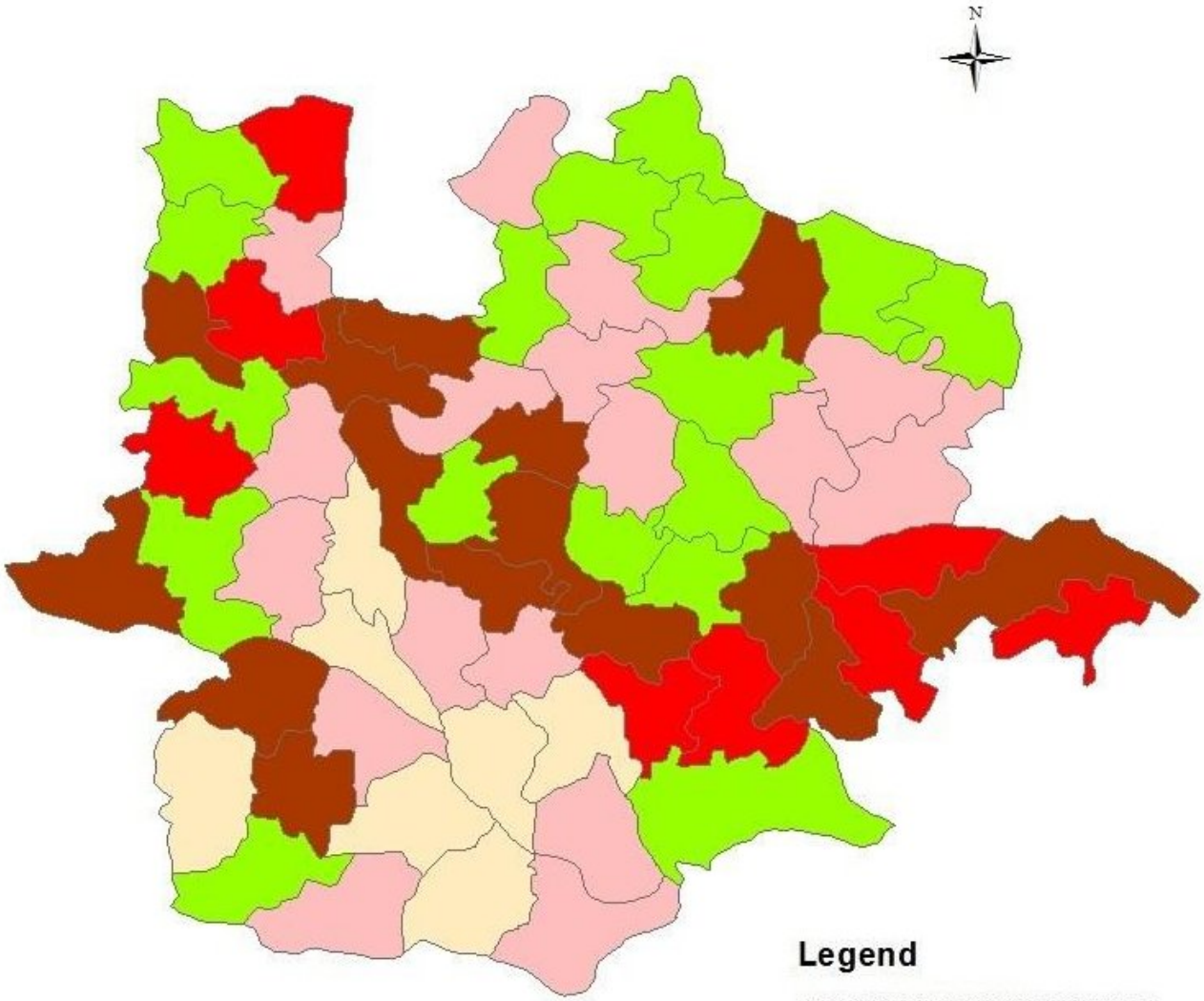
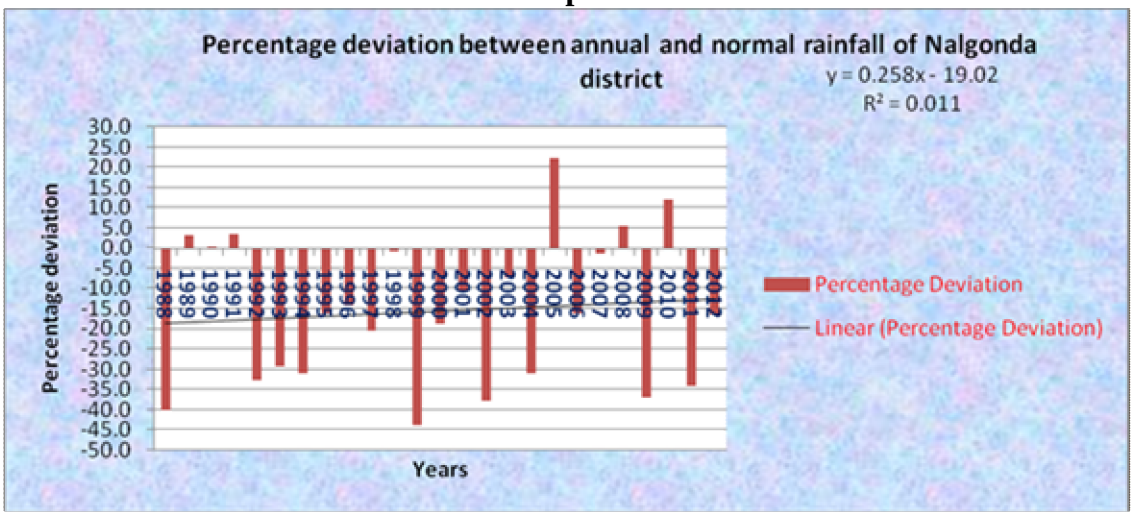


FIG-

NALGONDA

There are two distinct zones into which Nalgonda district can be divided.The Northern Telangana zone which has an annual rainfall, ranging between 900-1500mm.The other zone is the Southern Telangana zone with annual rainfall ranging between 700 to 800mm and this zone has been selected for further study.As far as temperature and rainfall is concerned data was collected for a period of twenty-five years. No significant change in temperature was observed in the district and the maximum and minimum temperatures remained almost constant.

Graph-3



The percentage deviation between the annual and normal rainfall in the Nalgonda district ranges from -43.7 to 22.2 percentage as shown in above graph. As the graph-3 shows there is a lot of deviation in the quantity of rainfall in the year 2004-2005 where the rainfall exceeds the normal rainfall of 752mm to 919mm showing 22.2 percentage deviations.In the year 1998-99the rainfall recorded was 423.6mm which was lower than the normal rainfall showing a -43.7percentage deviation.There is a decrease in the percentage deviation as is depicted by the linear trend.The above finding highlights the fact that there is a change in the rainfall pattern.The rainfall data at the mandal level was analysed for four mandals for a period of 25 years from 1988 to 2012.The result shows a marked deviation in the quantity of rainfall in different mandals of the district.In this study to understand the trends in rainfall during various seasons a breakup analysis according to the seasons was carried out at the district level.The agricultural patterns were correlated with the season wise analysis in individual mandals and its impact on agricultural productivity was analysed. The season wise analysis helped in bringing out the fact that maximum amount of rainfall occurred in the south west monsoon season (June to September) alone and July is the month that gets maximum rainfall (1117mm).

From the meteorological station located in Nalgonda mandal of the district, temperature data measurements were taken.It has been observed that temperature

touches the maximum during the months of April and May and from then on it decreases gradually by the time it is October.

The Southwest monsoon data and Northeast monsoon data were correlated with maximum and minimum temperature data. The correlation trends were compiled and from this compilation it was inferred that when the temperature increased the rainfall decreased.These facts are highlighted in Table-3.5.

Table-3.5:Correlation between the temperature and rainfall during Southwest monsoon and the Northeast monsoon.

Seasons	Maximum Average Temperature	Minimum Average Temperature
Southwest Monsoon	-0.003	-0.214
Northeast Monsoon	0.133	-0.254

The number of years below normal rainfall during both the monsoon seasons was analysed for 25 years.Out of these 25 years, 18 years recorded below normal rainfall during Southwest monsoon and 19 years during Northeast monsoon.The southwest monsoon contributes 80% of the rainfall.And the Northeast monsoon contributes only 10% of the rainfall.The trends observed are that there is a decrease in rainfall from around 711 mm in 1988 to 267 in the year 1994.When we consider the Northeast monsoon, the actual overate rainfall is below its normal 139mm and all these facts are highlighted in the table-3.6.

Table-3.6: Months with actual average rainfall below normal rainfall (mm) in Nalgonda District for a period between 1988-2012

Months	Number of Years below normal rainfall	Range of Percentage Deviation from normal rainfall for deficit years (below normal)	Normal Rain fall
June	18	-75 to -5.4	90.6
July	19	-81.7 to -7.4	170.9
August	19	-77.9 to -0.1	154.2
September	16	-84.4 to -1.6	146.1
SWM	**18**	**-53.2 to -2.85**	**561.8**
October	17	-84.2 to -1.8	102.4
November	19	-99.5 to 12.4	33.9
December	21	-100 to -28.8	3.4
NEM	**19**	**-61.1 to -3.3**	**139.7**

Fig-13A shows the distribution of the seasonal rainfall during the South West Monsoon for all the mandals of Nalgonda district and from the figure it is vivid that the mandals located in the north and north east boundary have received maximum rainfall and it is decreasing towards southwest. The highest rainfall received by the mandals is 550 mm – 631 mm and the least rainfall is between 273 to 267 mm.This is largely because of the topography of the area.Mandals like Kodad (631mm), Suryapet (621.3mm), Tungathurthy (613.8mm) received the highest rainfall.Whereas mandals

like Gundlapalli (273.0mm), Gurrampode (274.0mm), Chandampet (280.6mm) are received the least rainfall and the mandals that received the least rainfall are located at the southern part of the district.When there is a decline of rainfall in the months of July, September and October there is a corresponding decline in crop yield.

The *Fig*-13A shows the distribution of average southwest Monsoon rainfall in detail.Very high and high rainfall was recorded in the mandals of Turkapalli, Bommala-Ramaram, Bhongir, Yadagirigutta, Alair, Gundala, Valigonda, Bibinagar, Pochampally, Ramannapet, Thungathurthy, Nutankallu, Suryapet, Nalgonda, Kodad, Mungala, Damecherla, Kethepallri, Thirupuram, Miryalkudra, Guredapalli and Huzurnagar.The Southwestern part of the district where in the mandals like Gundlapally, Chandampet, Nampally, Gurrampode and Narayanpur recorded low to very low rainfall.

Further an analysis of the North East Monsoon as depicted in Fig 13B shows that two mandals to the west like Gurampode & NSP and two mandals to the east such as Mothey & Tirumalagiri received very less amount of rainfall.The rainfall is only in the range of 55 – 66mm, and those mandals that are northerly located such as Bibinagar, Bhongir, Pochampally and Chotuppal received maximum quantum of rainfall that ranged from 123.31 to 143.62mm.

The *Fig*-13B also shows the distribution of Northeast Monsoon rainfall, very high and high rainfall recorded in the mandals of Bibinagar, Pochampally, Bhongir, Veligonda, Tamanrape, Mothkur, Shali Gowraram, Nalgonda, Chandur, Miryalguda, Domeracherla, Thurkapally, Yadagirigutta, Alair, Chinthapally, Marriguda, Deverkonda, Peddavoora, Tripuraram, Nereducherla, Kodad, Munagala, Suryapet, Thungathurthy and Nutankallu.Only few mandals towards Southwest of the district such as Gundlapally, Chandampet, Gurrampode, Kangal and in the Southeastern part, a few mandals like Mattampally, Thirumalgiri, Atmakur and Mothey have recorded low to very low Northeast Monsoon rainfall.Rest of the mandals of the district received moderate rainfall.

For a period of 25 years the rainfall pertaining to each mandal was gathered and an analysis of the rainfall pattern was done. *Fig*-13C shows the percent deviation of rainfall from normal rainfall for all the 59 mandals during the period 1988 – 2012.

NALGONDA DISTRICT
AVERAGE SOUTHWEST MONSOON RAINFALL
1988-2012

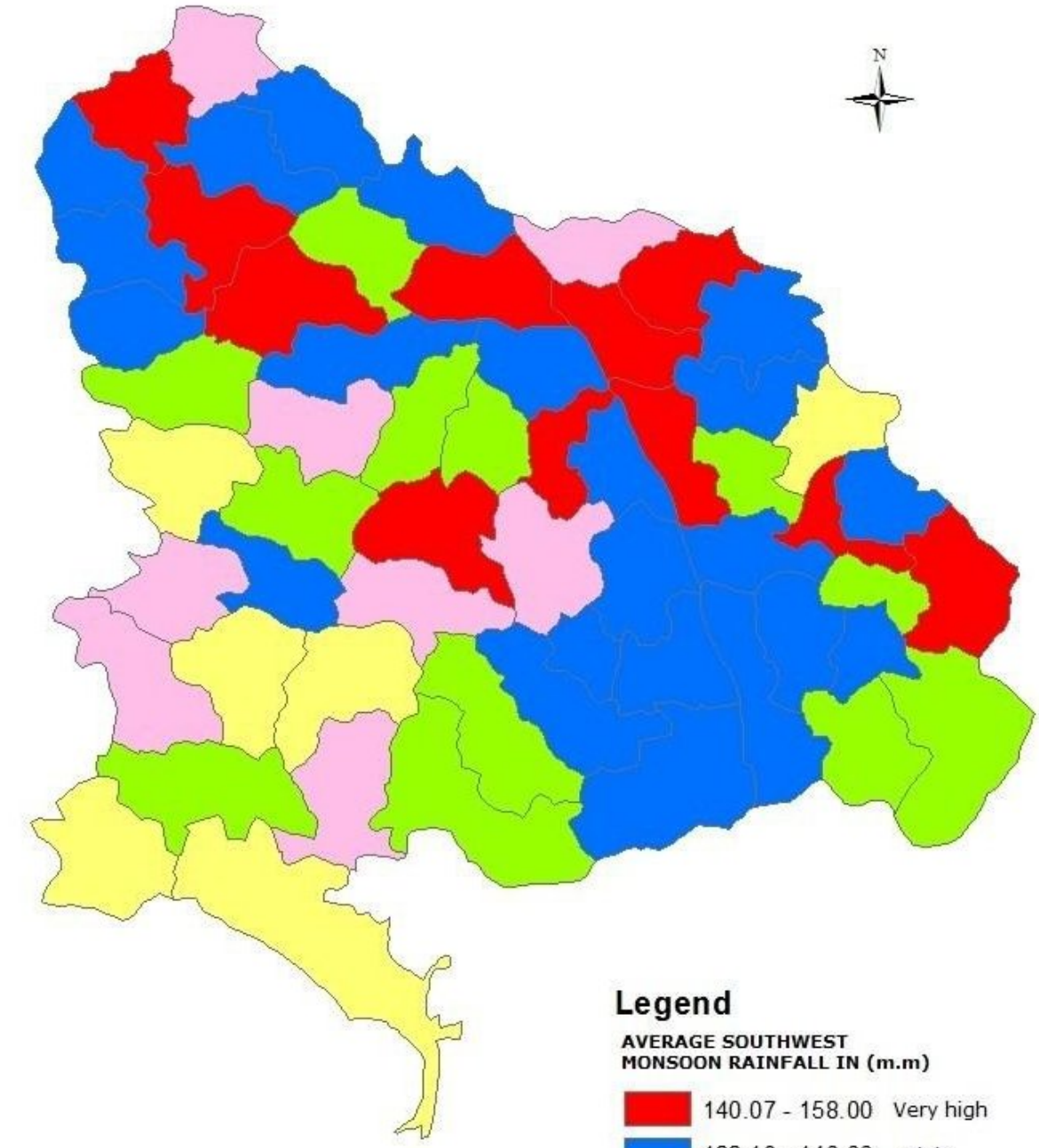


FIG-13 (A)

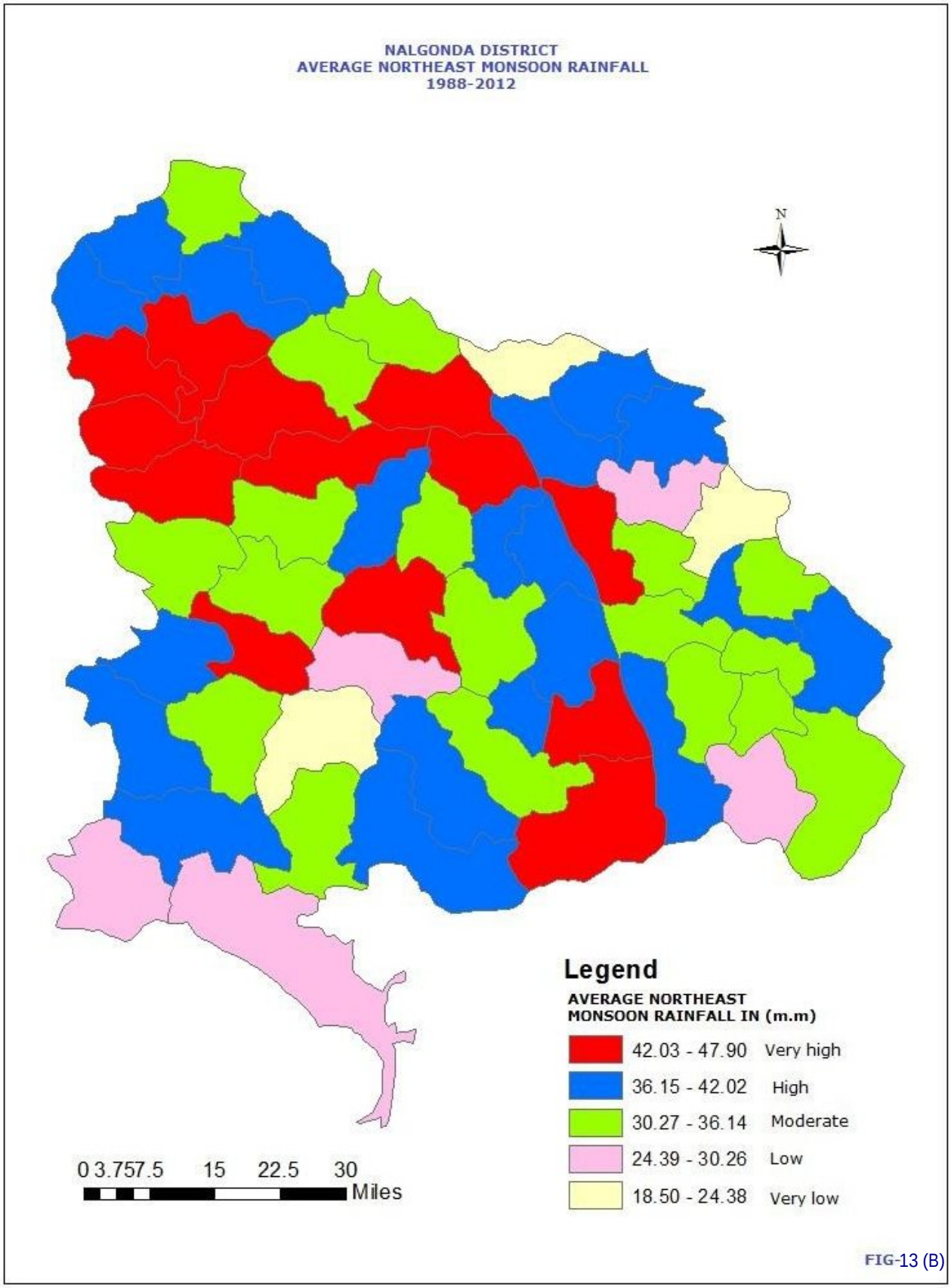

NALGONDA DISTRICT
AVERAGE NORTHEAST MONSOON RAINFALL
1988-2012
N
Legend
AVERAGE NORTHEAST
MONSOON RAINFALL IN (m.m)
42.03 - 47.90 Very high
36.15 - 42.02 High
30.27 - 36.14 Moderate
24.39 - 30.26 Low
18.50 - 24.38 Very low
0 3.757.5 15 22.5 30
Miles

FIG-13 (B)

NALGONDA DISTRICT
AVERAGE PERCENTAGE DEVIATION OF RAINFALL
1988-2012

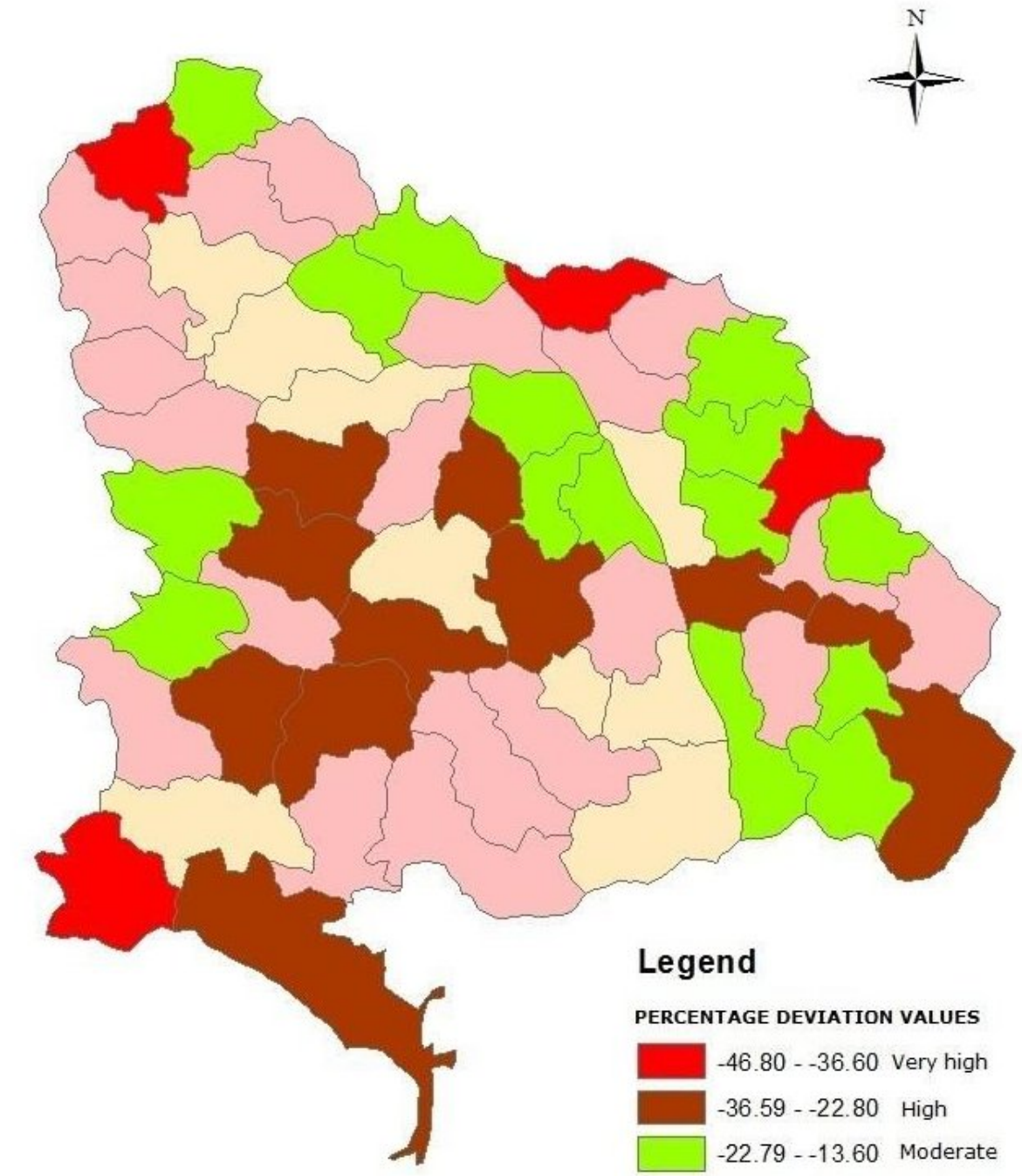
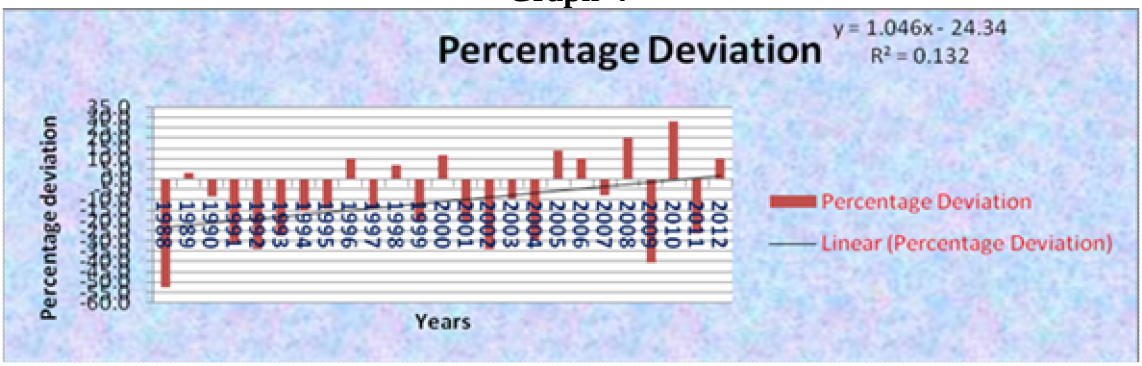


FIG-

WARANGAL DISTRICT

Warangal district falls in the central agroclimatic zone of the Telangana region.The normal annual rainfall of the district is 994mm.The rainfall increases from the Southwest to the Northeast part varying from 749 to 1285mm.The Southwest monsoon contributes about 80 percentage of the annual rainfall.

Graph-4



The Graph-4 shows the percentage deviation of rainfall for the last 25 years (1998-2012).The years 1988 and 2009 showed a vast deviation of -42 percentages and -32 percentages respectively which indicates that the rainfall recorded was less than the normal rainfall and the remaining eight years have shown a slight increase in actual rainfall received above the normal rainfall in the district.Overall the district recorded decrease in the amount of rainfall.

The correlation analysis was conducted between the minimum – maximum temperature and rainfall in the two seasons for the district. In both the seasons the correlation between rainfall and maximum temperatures was positive, however the average minimum temperature and Northeast monsoon showed a negative correlation (-0.063).This reveals insignificant decreases in seasonal rainfall.The following table-3.7 gives a clean picture about the same.

Table-3.7: Correlation between Temperature and Rainfall during Southwest and Northeast Monsoon in Warangal District

Seasons	Average Maximum Temperature	Average Minimum Temperature
Southwest Monsoon	0.168005	0.243598
Northeast Monsoon	0.131053	-0.06321

The temperature and the rainfall data were obtained from the IMD. Annual trends of changes in rainfall and temperature have been analysed for a period of 25 years in the district. Seasonal trends of rainfall and the number of years with deficit rainfall in the district. In the Southwest monsoon season out of the 25 years, 16 years were recorded below normal rainfall and in the Northeast monsoon period 18 years were recorded below normal rainfall. In both the seasons most of the years recorded

rainfall below normal.The range of percentage deviation from normal for the deficit years is highlighted in the following table-3.8.

Table-3.8: Months with actual average rainfall below the normal rainfall (mm) in Warangal District for a period between 1988-2012

Months	Number of Years below normal rainfall	Range of Percentage Deviation from normal rainfall for deficit years (below normal)	Normal Rain fall
June	16	-82.3 to -5.2	137.2
July	18	-69.5 to -1.3	287.7
August	17	-62.2 to -3.6	238.3
September	12	-84.7 to -0.8	135.8
SWM	**15.75**	**11.7 to-6.1**	**199.75**
October	15	-90.7 to -5.9	86.5
November	18	-99.6 to -6.5	27.1
December	21	00 to -46.1	6.4
NEM	**18**	**19.6 to -12.9**	**40**

The *Fig*-14A shows the distribution of Southwest Monsoon rainfall for a period of 25 years.Very high and high rainfall in this season was recorded towards the North Eastern part of the district, they cover the mandals of Eturu Nagaram,Mangampet, Tadvai, Mulug, Govindaraopet, Bhupalpally, Venkatapur, Kothagudam, Narsampet, Gudur, Mahabubabad, Nalabilli, Khanapur, Parkal, Shyampet and Atmakur. Low and very low Southwest Monsoon rainfall was recorded in the Southern and Southeastern part of the district.Very few mandals such as Chityal, Mogulapalli, Regonda, Ghanpur, Hasanparthi, Hanumakonda and Dornakal recorded moderate Southwest monsoon rainfall.

The *Fig*-14B depicts the distribution of Northeast Monsoon rainfall. Very high and high rainfall was recorded in the central and eastern part of the district covering the mandals of Eturnagaram, Dornakal, Jangaon, Palakurthy, Hanmakonda, Sangam, Mangampet, Nallaballi, Thorur, Hasanparthi, Atmakur and Bachannapet. Very low rainfall was recorded towards north western tip of the district covering the mandals *viz.* Chityal, Mogulapalle, Regonda, Parkal, Ghanpur, Venkatapur and western part of the district covering Cherial, Maddur etc… Remaining mandals recorded moderate to low rainfall during north-east monsoon season.

The average percentage deviation of rainfall is shown in the *Fig*-14C where very high and high percentage deviation was recorded in the mandals of Eturunagaram, Tadvai, Mulug, Ghanpur, Parkal, Shyampet, Gudur, Chemmanaraopet, Sangam, Mahabubabad, Dornakal, Dharmasagar, Maddur, Narmetta and Jangaon.Low to very low percentage deviation was recorded in the southern and southeastern parts of the district. The rest of the mandals recorded a moderate percentage deviation of rainfall.

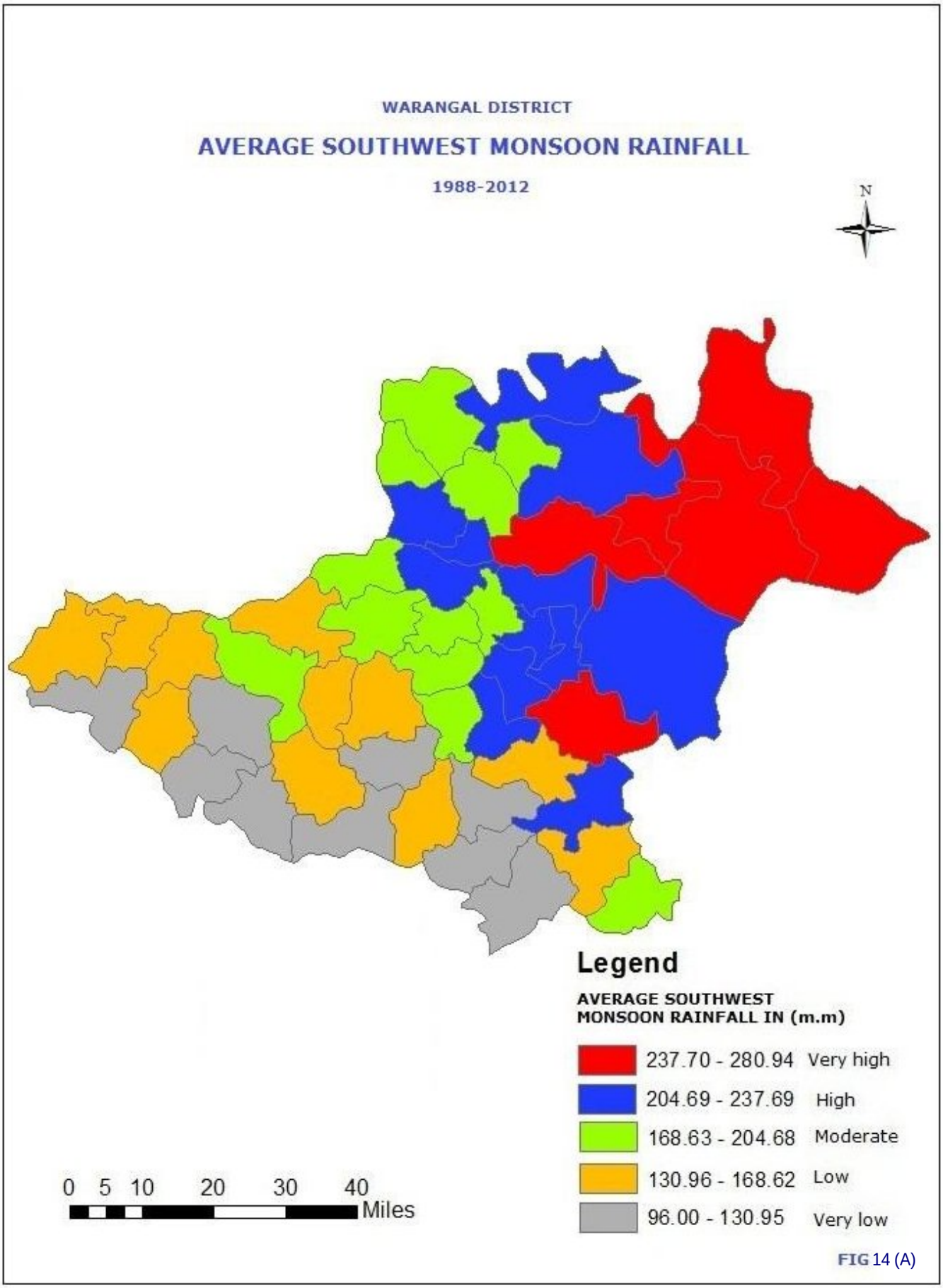

WARANGAL DISTRICT
AVERAGE SOUTHWEST MONSOON RAINFALL
1988-2012
N
Legend
AVERAGE SOUTHWEST MONSOON RAINFALL IN (m.m)
237.70 - 280.94 Very high
204.69 - 237.69 High
168.63 - 204.68 Moderate
130.96 - 168.62 Low
96.00 - 130.95 Very low
0 5 10 20 30 40
Miles

FIG 14 (A)

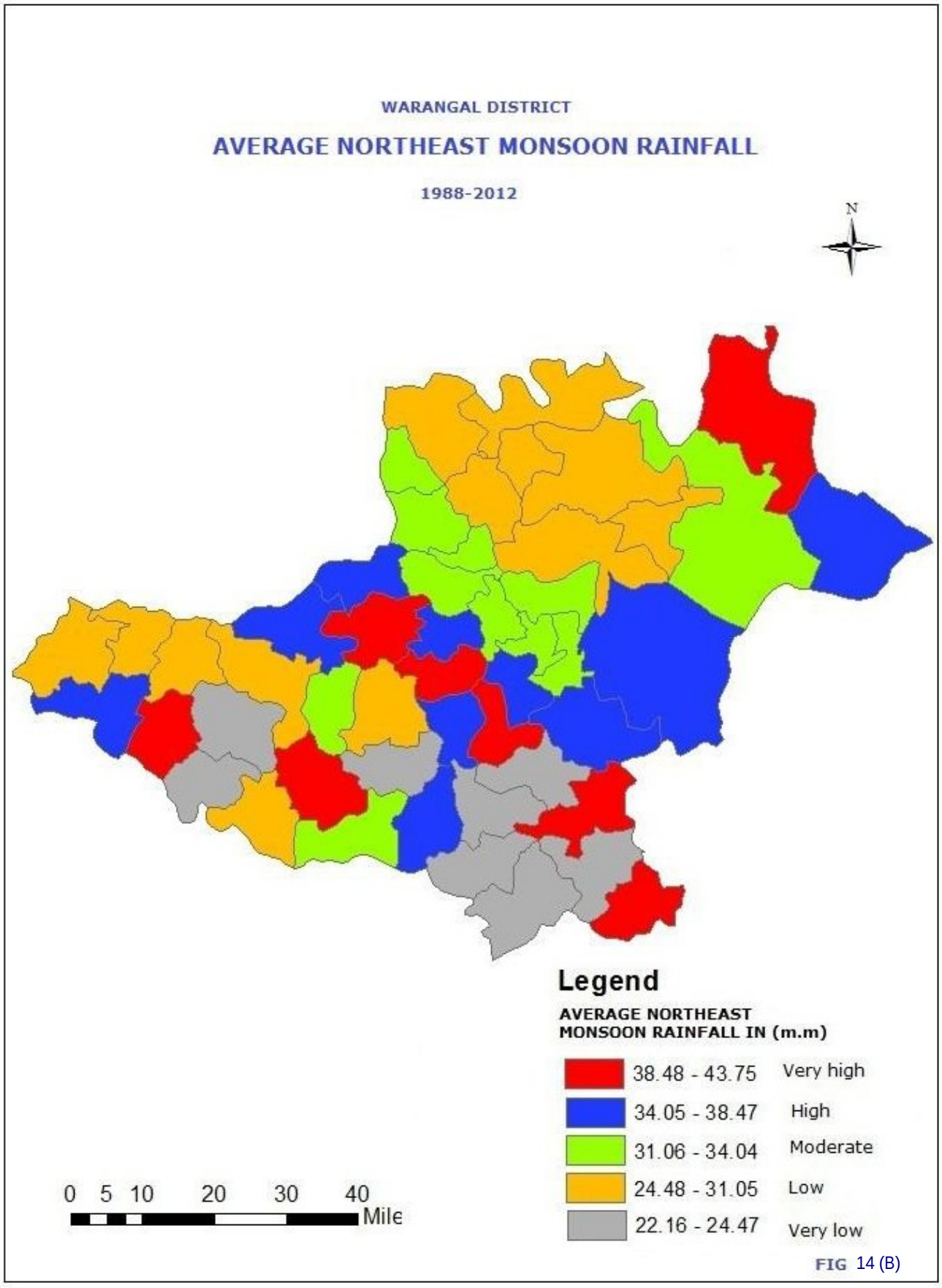
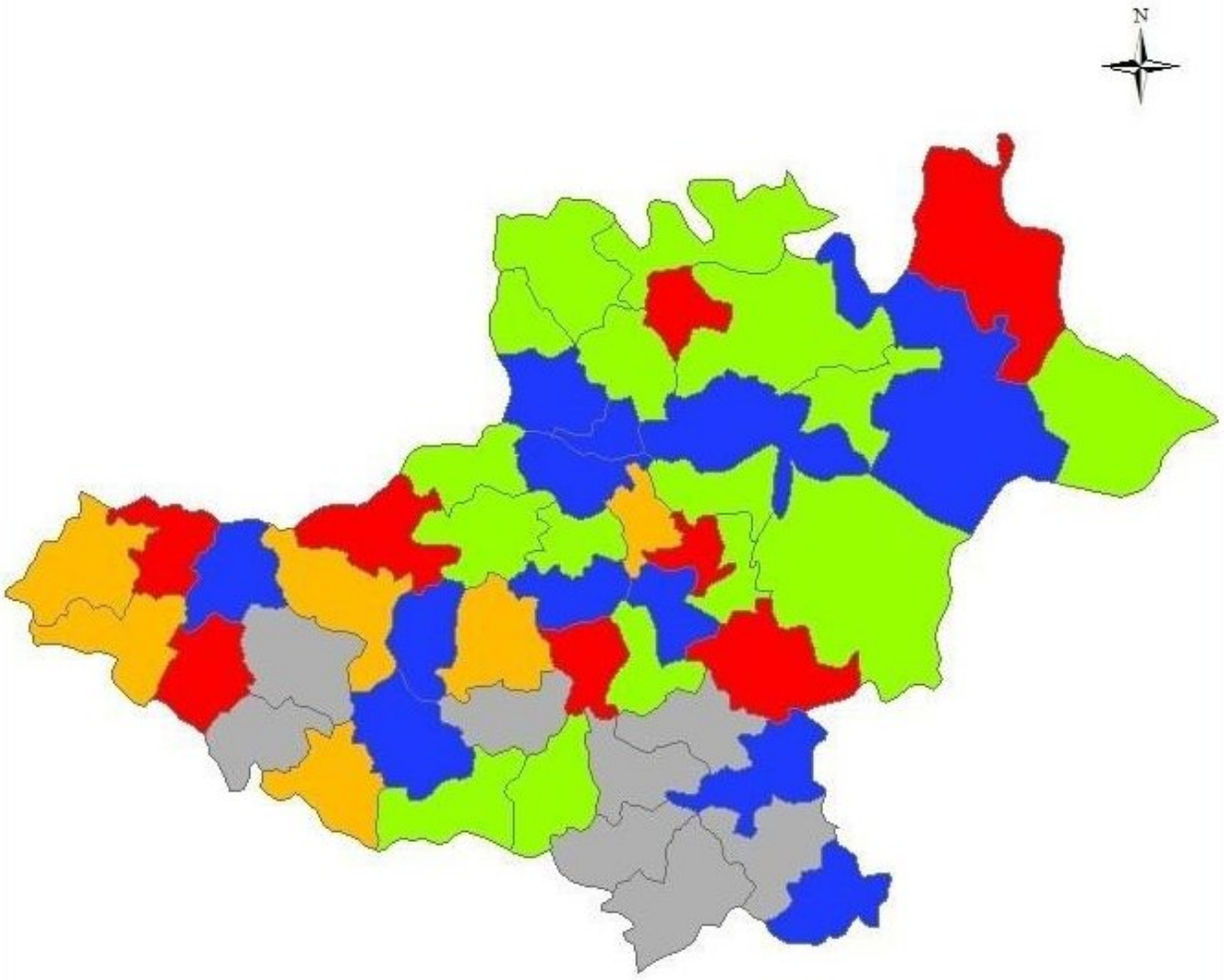

WARANGAL DISTRICT
AVERAGE NORTHEAST MONSOON RAINFALL
1988-2012
N
Legend
AVERAGE NORTHEAST MONSOON RAINFALL IN (m.m)
38.48 - 43.75 Very high
34.05 - 38.47 High
31.06 - 34.04 Moderate
24.48 - 31.05 Low
22.16 - 24.47 Very low
0 5 10 20 30 40
Mile

FIG 14 (B)

WARANGAL DISTRICT

AVERAGE PERCENTAGE DEVIATION OF RAINFALL

1988-2012



Legend

PERCENTAGE DEVIATION VALUES

-41.20 - -31.70	Very high
-31.69 - -12.50	High
-12.49 - -5.20	Moderate
-5.19 - -0.70	Low
-0.69 - 13.40	Very low

0 5 10 20 30 40 Miles

FIG 14 (C)

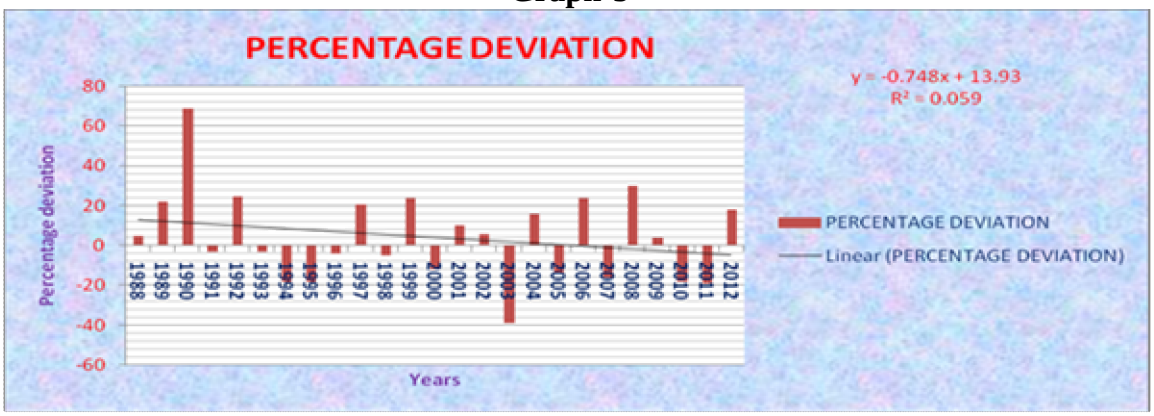
COASTAL ANDHRA REGION

Two districts from a single agroclimatic zone (the Krishna Agroclimatic zone) of the coastal region in the State of Andhra Pradesh were selected for the study.The two districts selected were Krishna and Guntur districts.

GUNTUR DISTRICT

Guntur district is one of the central coastal districts of the Andhra Pradesh state. It belongs to Krishna agroclimatic zone. The annual normal rainfall received by the district is 815mm. Southwest monsoon period of the district receives 70 percentage of the rains during this season. Rest of the 30percentage rainfall received by the district is through north east monsoon. Rain storms and cyclones are common in Guntur district.

Graph-5



The graph-5 shows the percentage deviation between normal and annual rainfall of the district. During 1988 to 2012 the district showed erratic percentage deviation.

The linear trend of percentage deviation showed a declining trend from 1988 to 2012. The maximum positive percentage deviation was recorded in 1990 with +69 percentage and the negative percentage deviation was recorded in 2003 with -40 percentage deviation.

Table-3.9: Correlation between the Temperature and Rainfall during Southwest and Northeast Monsoon in Guntur District

Seasons	Average Maximum Temperature	Average Minimum Temperature
Southwest Monsoon	-0.32786	0.223481
Northeast Monsoon	-0.18006	0.301569

The Correlation between the temperature (average minimum and maximum) and rainfall during both the seasons (Southwest and Northeast Monsoon seasons) is shown in the above table-3.9. There is a negative relationship between both the monsoon seasons and the maximum temperature.It indicates that when the temperature increases the rainfall decreases.

The following table-3.10 shows the total number of years, where in the rainfall received in the district is below normal.During the Southwest Monsoon season about 15 years recorded below normal rainfall out of 25 years, and during the Northeast Monsoon season 17 years received below normal rainfall.The range of percentage deviation from normal rainfall for the deficit years during Southwest Monsoon season was -46.62 to -1.81 and for the Northeast Monsoon season it was -78.25 to -1.76.The variation in rainfall during Northeast Monsoon season was more when compared to the Southwest Monsoon season.

Table-3.10: Months with actual average rainfall below the normal rainfall (mm) in Guntur District for a period between 1988-2012

Months	Number of Years below normal rainfall	Range of Percentage Deviation from normal rainfall for the deficit years (below normal)	Normal Rain fall
June	15	-72.6 to -1.8	86.3
July	14	-80.9 to -11.3	142.1
August	14	-68.0 to -9.3	152.0
September	15	-77.3 to -11.1	145.4
SWM	**14.5**	**-46.62 to -1.81**	**131.45**
October	13	-87.3 to -1.3	130.5
November	19	-99.6 to -0.1	82.0
December	20	00 to -10.3	16.4
NEM	**17.33**	**-78.25 to -1.76**	**76.3**

The average Southwest monsoon rainfall distribution in all the mandals of the district is shown in the *Fig*-15A major portion of the rainfall in the district was received during this season. Very high rainfall was recorded in Amaravathi, Dugirala, Peddakakkani and high rainfall to moderate rainfall was recorded in the mandals located near the sea coast and northern parts of the district.

The *Fig*-15B shows the distribution of north east monsoon rainfall mandal wise in the district of Guntur. Very high to high rainfall was recorded in the mandals of Bapatla, Nizampatnam, Repalle, Nagaram and Amarthalur. These mandals are close to the sea coast. Rest of the mandals showed moderate to low average rainfall during this season.

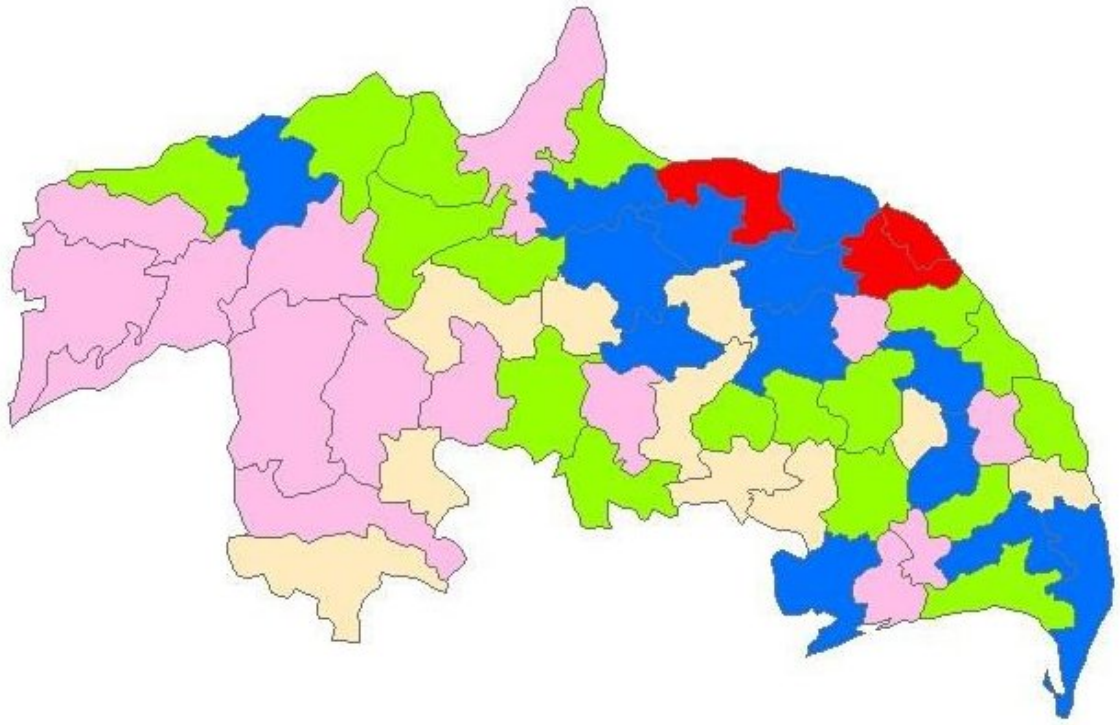
The average percentage deviation of rainfall for all the mandals of the district is shown in the *Fig*-15C very high to high percentage deviation of rainfall i.e., negative deviation was found in the mandals of Savalyapuram, Nekarikallu, Muppala, Pedanamidipadu, Medikonduri, Kakumanur, Karlapalem, Tsundur Vemur and Bhattiprolu. All these mandals received less rainfall i.e., the annual rainfall of moderate percentage deviation of rainfall was seen in Durgi, Karempadi,

Bellamkonda, Kollur and Kollipara mandals. Low and very low percentage deviation of rainfall was recorded in the rest of the mandals; it indicates that these mandals received more amount of annual rainfall than the normal.

GUNTUR DISTRICT

AVERAGE SOUTHWEST MONSOON RAINFALL

1988-2012



Legend

AVERAGE SOUTHWEST MONSOON RAINFALL IN (m.m)

169.07 - 193.10	Very high
145.03 - 169.06	High
120.99 - 145.02	Moderate
96.95 - 120.98	Low
72.90 - 96.94	Very low

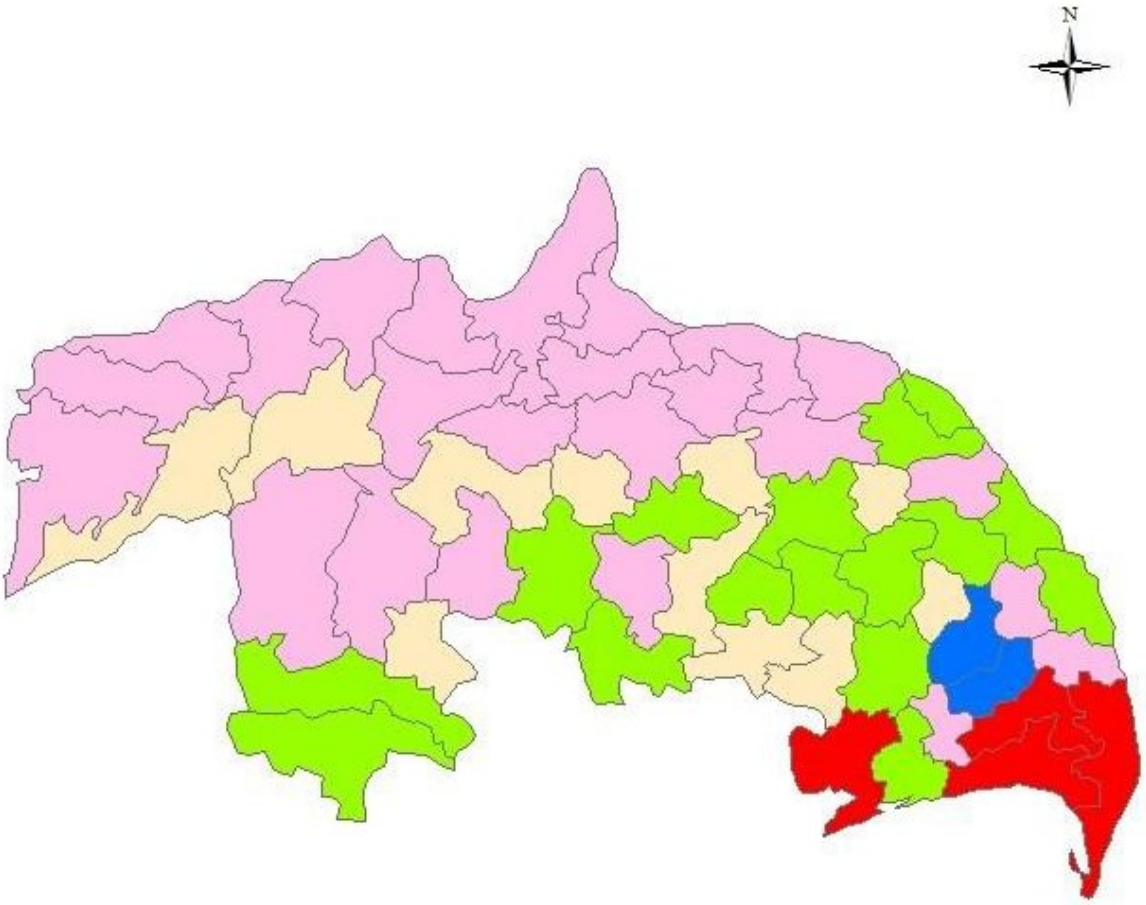
0 5 10 20 30 40 Miles

FIG-15 (A)

GUNTUR DISTRICT

AVERAGE NORTHEAST MONSOON RAINFALL

1988-2012



Legend

AVERAGE NORTHEAST MONSOON RAINFALL IN (m.m)

103.37 - 122.00	Very high
84.73 - 103.36	High
66.09 - 84.72	Moderate
47.45 - 66.08	Low
28.80 - 47.44	Very low

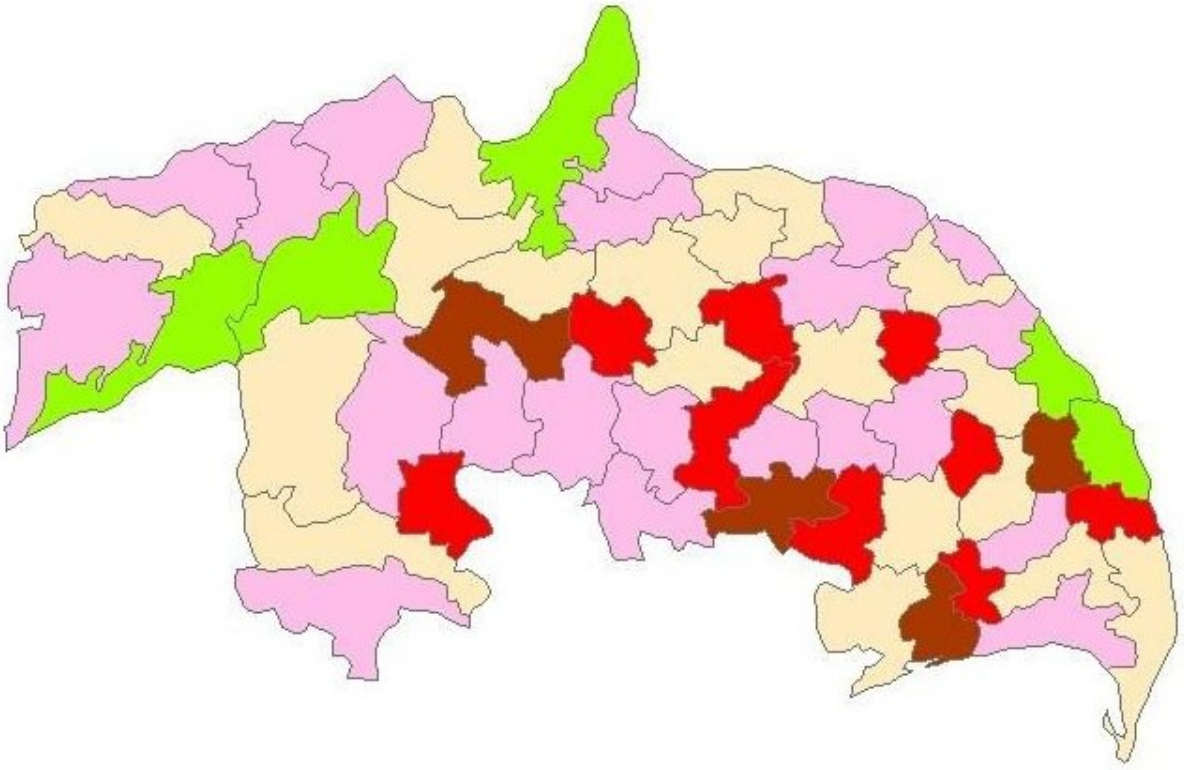
0 5 10 20 30 40 Miles

FIG-15 (B)

GUNTUR DISTRICT

AVERAGE PERCENTAGE DEVIATION OF RAINFALL

1988-2012



Legend

Percentage Deviation values

-45.50 - -33.40	Very high
-33.39 - -21.30	High
-21.29 - -9.20	Moderate
-9.19 - 2.90	Low
2.91 - 15.00	Very low

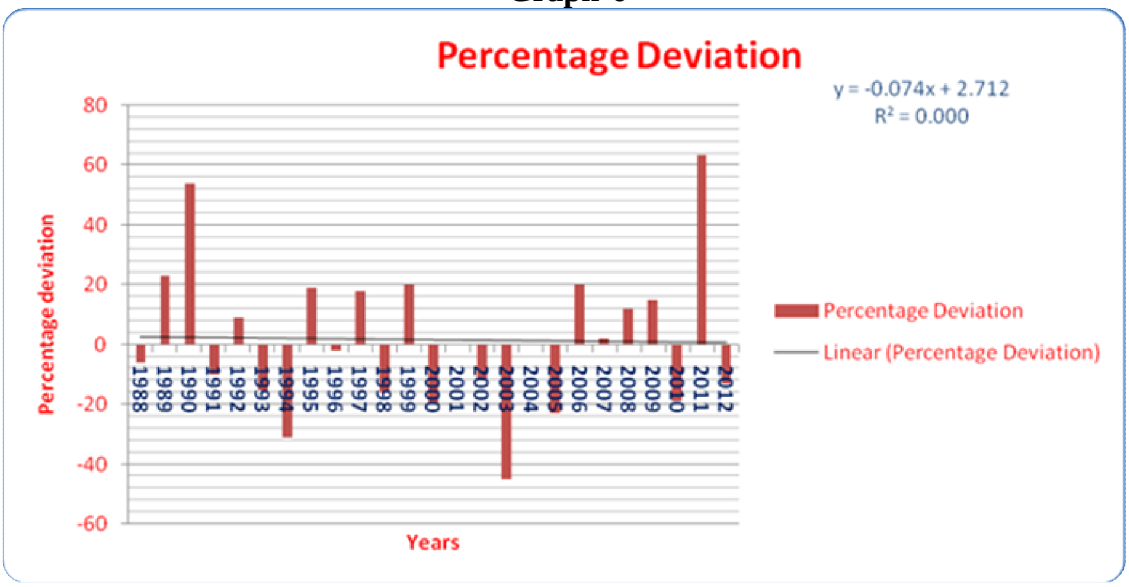
0 4.759.5 19 28.5 38
Miles

FIG-15 (C)

KRISHNA DISTRICT

The Krishna district experiences summer from March to June.The temperature recorded in summer is very high, as high as 50^0C which was registered during 2007 at Gannavaram (IMD observatory).Consecutive droughts between the years 2000 and 2002 caused crop failure. The South west monsoon season is from July to September. The district receives heavy rainfall during these months. About two third of the total rainfall of the district is brought about by the Northeast monsoon. October and November experiences low pressure systems and the tropical cyclones formed in the Bay of Bengal along with the Northeast monsoon bring rains to the coastal districts of the state.

Graph-6



The graph-6 shows the percentage deviation between annual and normal rainfall in the Krishna district. Positive percentage deviation of 53 percentages in 1990 and 62 percentage in 2011 was recorded in the district. Negative percentage deviation was recorded during the years 1994, 1998, 2000, 2002, 2003, 2005, 2010 and 2012.

The summer climate of Krishna district is between March and June.The temperature recorded in summer is very high and as high as 50^0C which was registered during 2007 at Gannavaram (IMD observatory).Consecutive droughts between 2000 and 2002 caused crop failure.

The correlation between temperature and rainfall during Southwest and Northeast monsoon in the district is shown in the following table-3.11.

Table-3.11: Correlation between the Temperature and Rainfall during Southwest and Northeast Monsoon in Krishna District

Seasons	Average Maximum Temperature	Average Minimum Temperature
Southwest Monsoon	0.104392	0.223646
Northeast Monsoon	0.128007	0.30766

The following table-3.12 shows the total number of years that rainfall below normal was received in the district. In the Southwest monsoon season about 15 years recorded below normal rainfall out of the 25 years and during Northeast monsoon, 18 years received below normal rainfall. The range of percentage deviation from normal rainfall for the deficit years during Southwest monsoon season was -46.62 to -1.81 and for Northeast monsoon season it was -78.25 to -1.76.The variation in rainfall during Northeast monsoon season was more when compared to the Southwest monsoon season.

Table-3.12: Months with actual average rainfall below the normal rainfall (mm) in Krishna District for a period between 1988-2012

Months	Number of Years below normal rainfall	Range of Percentage Deviation from normal rainfall for deficit years (below normal)	Normal Rain fall
June	13	-74.5 to -11.7	97.8
July	16	-64.9 to -6.0	210.6
August	17	-80.6 to -10.8	212.8
September	16	-75.4 to -3.1	163.9
SWM	**15.5**	**-54.30 to -4.68**	**171.27**
October	16	-86.9 to -0.8	162.7
November	18	-98.0 to -3.3	70.7
December	19	-100 to -25.6	16.0
NEM	**17.66**	**-82.35 to -0.25**	**83.13**

The *Fig*-16A shows the distribution of south west monsoon rainfall of all the mandals of Krishna district (25 years average). Very high south monsoon rainfall was recorded in Tiruvur and Vissanapeta mandals. (The north eastern and north western parts of the district experience heavy rains during the south west monsoon season). High rainfall was recorded in the mandals of Gampalagudem, Reddigudem, Chatrai, Nuzvid, Agripalli, Mailavaram, G Konduru, Veerullapadu, Nandigama, Vatsavi, Ibrahimpatnam and Avanigadda. The remaining mandals recorded moderate to low rainfall during this season.

The *Fig*-16B shows the average north east monsoon rainfall (1988-2012) for all the mandals of the district. The southern mandals such as Nagayalanka, Koduru, Avanigadda, Machilipatnam. Gantasala recorded very high to high Northeast monsoon rainfall. Moderate rainfall during this season was recorded in the mandals of

Movva, Krithivennu, Bantumilli and Pedana. Remaining mandals recorded low to very low rainfall during this season.

The distribution of average percentage deviation of rainfall for all the mandals of the district is shown in the *Fig*-16C Very high to high percentage deviation was recorded in Thotlavalluru, Vuyyuru, Gudlavalleru, Goburu, Nandivada, Mudinepalli, Vijayawada and Kalidindi mandals. Moderate percentage deviation of rainfall was recorded in the mandals of Veerulapadu, Kanchikacherla, Vijayawada (U), Pamarru, Ghantasala and Pedana. Remaining mandals showed low to very low percentage deviation.

The low to very low percentage deviation in these mandals indicates that there is not much variation in the rainfall distribution. These mandals experienced more rainfall than the normal rainfall.

KRISHNA DISTRICT

AVERAGE SOUTHWEST MONSOON RAINFALL

1988-2012

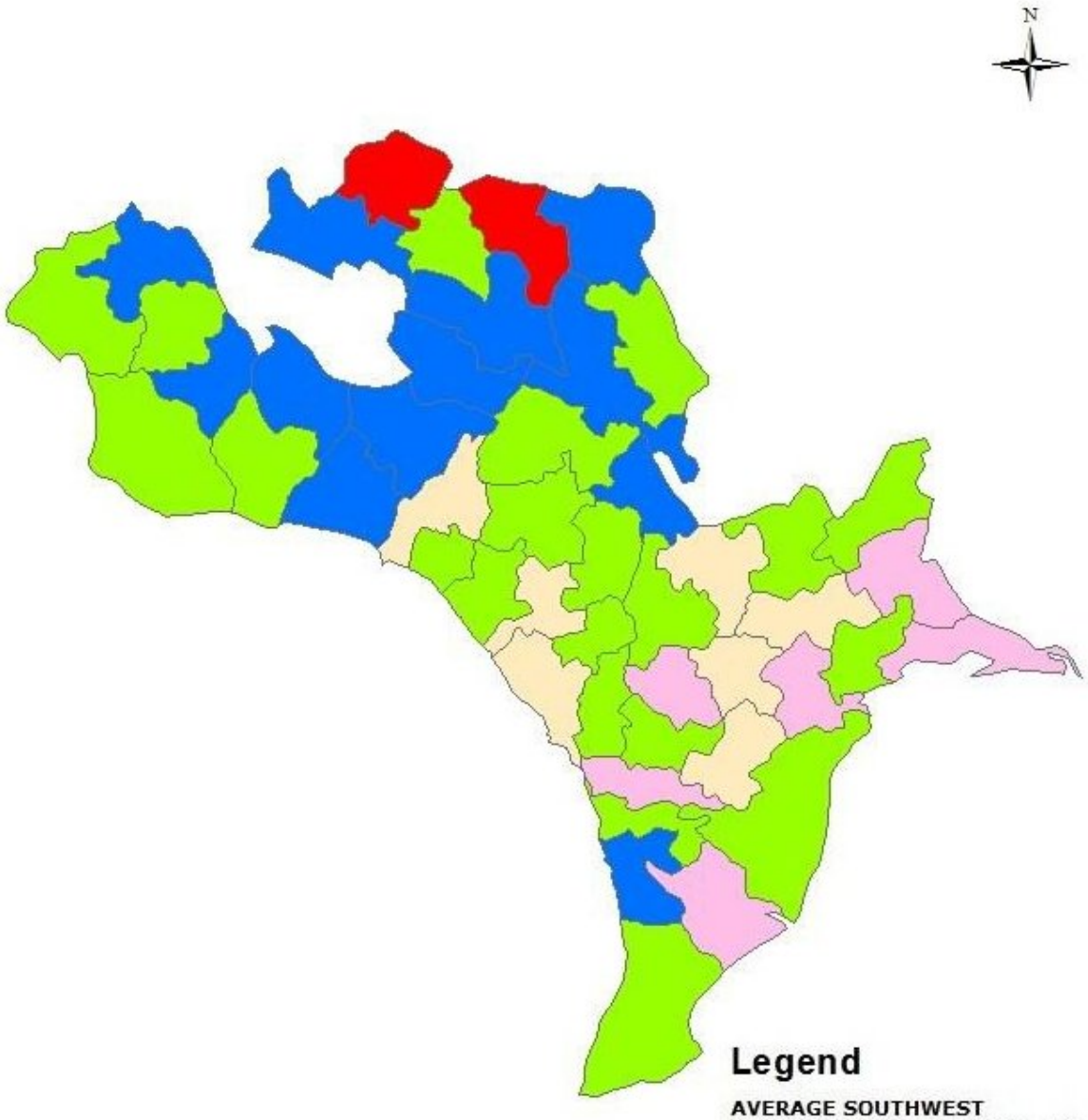


FIG-16 (A)

KRISHNA DISTRICT

AVERAGE NORTHEAST MONSOON RAINFALL

1988-2012

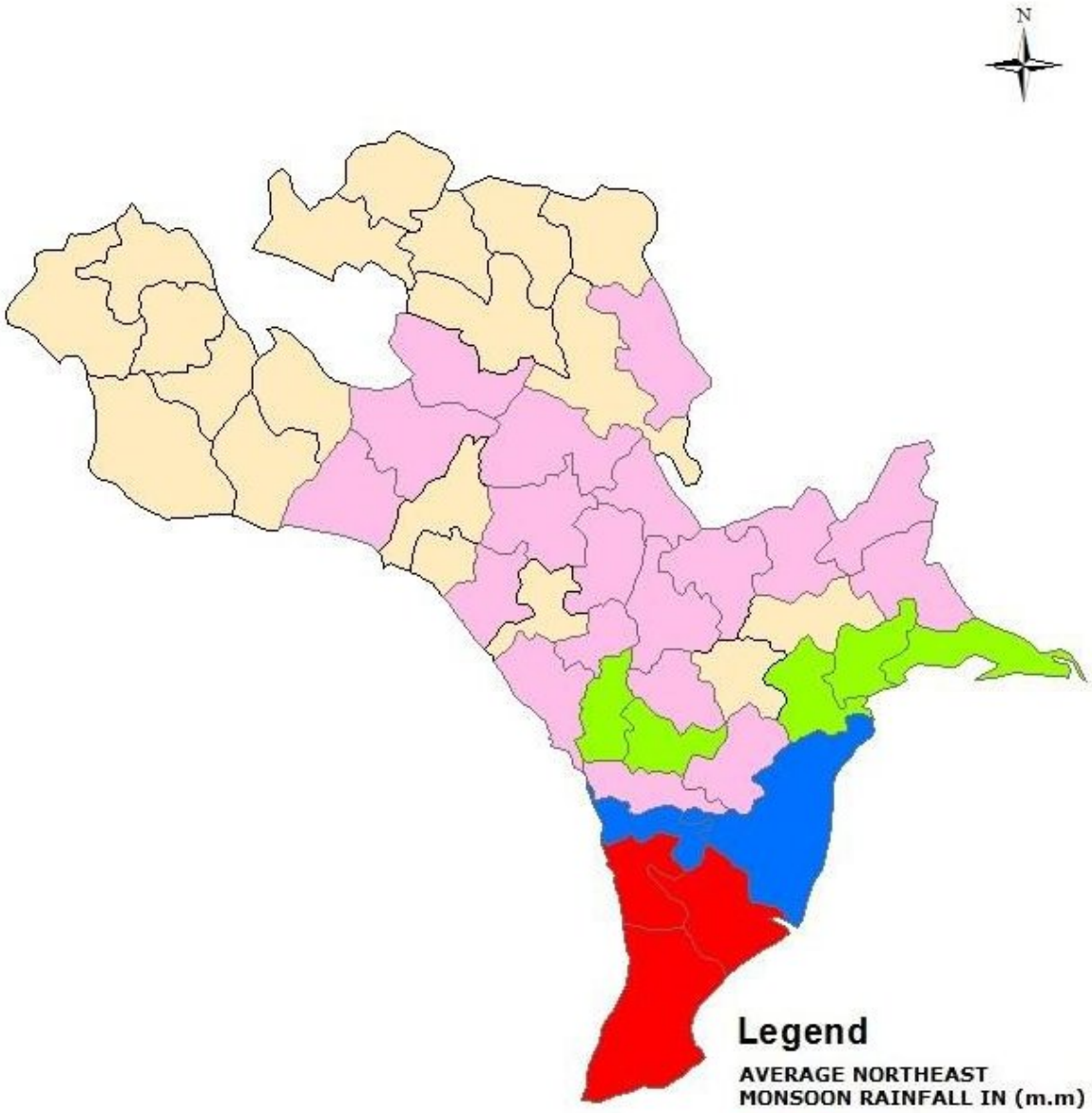


FIG-16 (B)

KRISHNA DISTRICT

AVERAGE PERCENTAGE DEVIATION OF RAINFALL

1988-2012

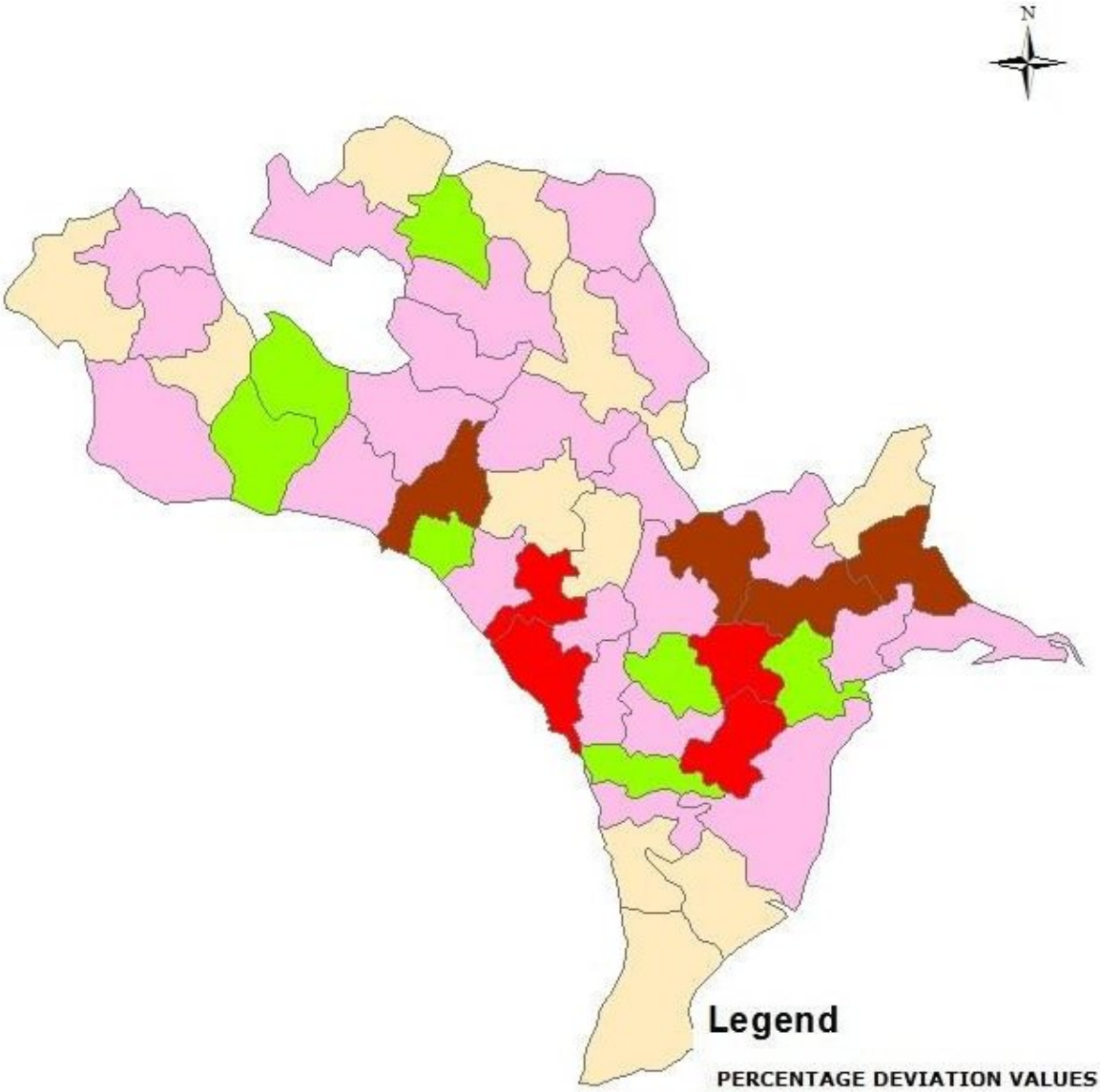


FIG16 (C)

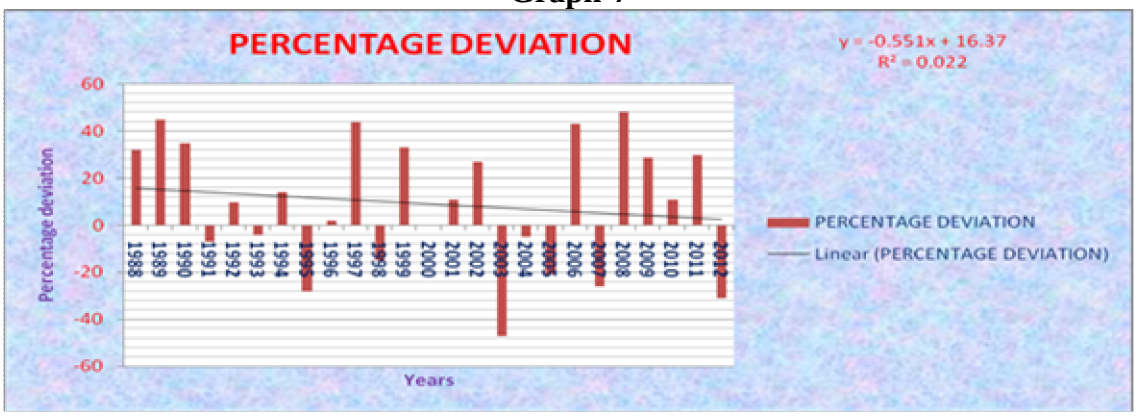
RAYALASEEMA REGION

In the Rayalaseema region the two districts chosen from a single agroclimatic zone – the scarce rainfall districts were Ananthapur and Kurnool districts.

ANANTHAPUR DISTRICT

This district is located in the rain shadow zone of the state. Climatologically the district lies in the dry sub humid type of climate. Ananthapur district is in the Agroclimatic zone with scarce rainfall and is marked by hot arid bioclimatic condition with dry summers. Both Southwest and Northeast monsoon does not give any benefit to the region. The Southwest monsoon gets cut off by the Western Ghats, while the benefit of the Northeast monsoon is not derived as well, since the district lies far away from the eastern coastline. The normal rainfall received by the district is not more than 550mm. In more than one of the years studied, the actual rainfall recorded was below the annual mean rainfall of 550mm. On an average once in every five years, the district experiences drought conditions.

Graph-7



The years 1989, 1997, 2006 and 2009 showed positive percentage deviation of rainfall and the years 1995, 2003, 2005, 2007 and 2012 have showed negative percentage deviation ranging between -25% to -48% in the above graph-7.

Table-3.13: Correlation between the Temperature and Rainfall during Southwest and Northeast Monsoon in Ananthapur District

Seasons	Average Maximum Temperature	Average Minimum Temperature
Southwest Monsoon	-0.51876	-0.36375
Northeast Monsoon	0.543678	0.254648

With the increase of rainfall during Southwest Monsoon season the temperatures gradually come down and this is evident from data of correlation shown

in the table-3.13.In contrast the temperature gradually increases during the Northeast Monsoon season in spite of recording scanty rainfall, hence a positive (0.543) correlation was found between rainfall and temperature. During the Southwest Monsoon season, because of more humidity percentage in the air, the minimum temperature will not be dropped down much, hence it was found that a negative (-0.363) correlation existed between the rainfall and minimum temperature.

In the Northeast Monsoon season (winter season) very less humidity was recorded in the air because of which the minimum temperature dropped down steeply, which indicates positive correlation (0.25) between the temperature and rainfall. During this period very, less rainfall was observed and therefore the positive correlation was not significant.

The following table-3.14 shows that the number of years of rainfall in the district was below the normal.It was observed that out of the 25 years, about 15 years received below normal rainfall and 10 years showed above the normal values during the Southwest Monsoon season.The range of percentage deviation was found to be between -89.1 to -2.2.This shows that, there is more variation in rainfall in the district.

Even in the Northeast Monsoon season, 15 years recorded below normal rainfall and 10 years showed above normal rainfall.The range of percentage deviation was found to be between -99.7 and -2.4, which also indicates more variation in rainfall during this season for the district.

Table-3.14: Months with actual average rainfall below normal rainfall (mm) in Ananthapur District for a period between 1988-2012

Months	Number of Years below normal rainfall	Range of Percentage Deviation from normal rainfall for deficit years(below normal)	Normal Rain fall
June	15	-72.6 to -1.8	86.3
July	14	-80.9 to -11.3	142.1
August	14	-68.0 to -9.3	152.0
September	15	-77.3 to -11.1	145.4
SWM	**14.5**	**-46.62 to -1.81**	**131.45**
October	13	-87.3 to -1.3	130.5
November	19	-99.6 to -0.1	82.0
December	20	00 to -10.3	16.4
NEM	**17.33**	**-78.25 to -1.76**	**76.3**

The *Fig*-17A shows the distribution pattern of Southwest monsoon in each mandal (25 years average). Very high rainfall was recorded in the mandals of Mudigubba, Bukkapatnam, Kothacheruvu, Penukonda, Kadiri and Tadpatri. High rainfall was recorded in the mandals of Hindupur, Somandepalli, Puttaparthi, Dharmavaram, Ananthapur, Bukkarayasamudram, Vidupanakal, Guntakal, Gooty and Rolla. Very low Southwest monsoon rainfall was recorded in Kambandur and

Chennakotapalli mandal. Remaining mandals of the district showed moderate to low average southwest monsoon rainfall.

The *Fig*-17B shows the distribution of Northeast rainfall in the mandals of Ananthapur district. Very high to high rainfall was recorded in the South eastern part of the district covering the mandals of Mudigubba, Talupula, Kadiri, Gandlapenta, Narlacheruvu, Tanakal,Amadagur,Obuladevara Cheruvu, Gorantla, Penukonda, Puttaparthi, Nallamada and Bukkapatnam. Moderate to low rainfall prevailed in all the mandals.

The *Fig*-17C shows the average percentage deviation of rainfall in all the mandals of the district for the period 1988-2012. Very high to high negative percentage deviation was recorded in the mandals of Talapula, Yadiki, Garladinne, Yellanur and Roddam. Very low percentage deviation was observed in three mandals of the district, these mandals are Bommanahal, Kudair and Atmakur. Remaining mandals of the district showed moderate to low percentage deviation. This clearly indicates the severity of drought and its impact on the agricultural prospect of the district.

ANANTHAPUR DISTRICT

AVERAGE SOUTHWEST MONSOON RAINFALL

1988-2012

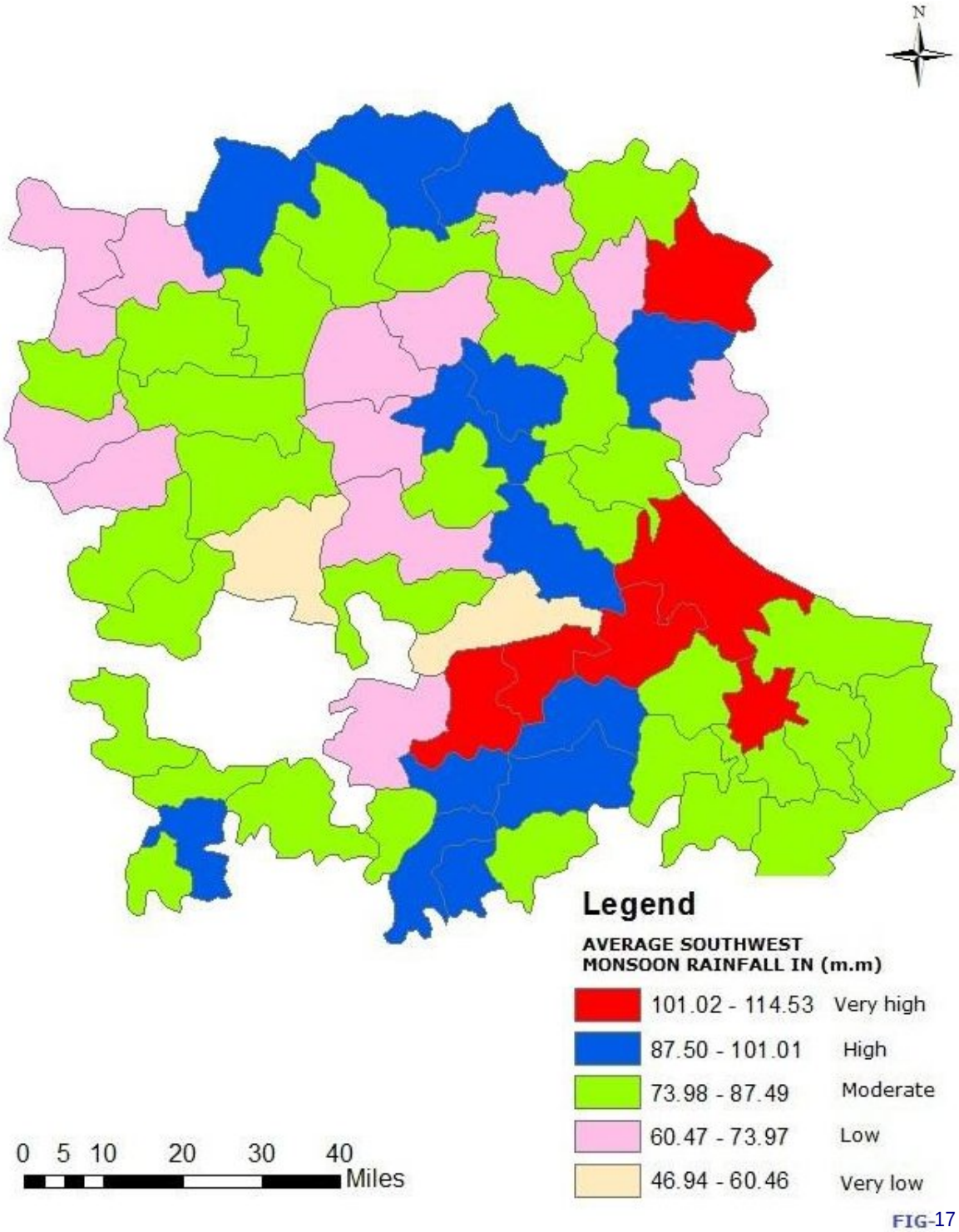


FIG-17 (A)

ANANTHAPUR DISTRICT

AVERAGE NORTHEAST MONSOON RAINFALL

1988-2012

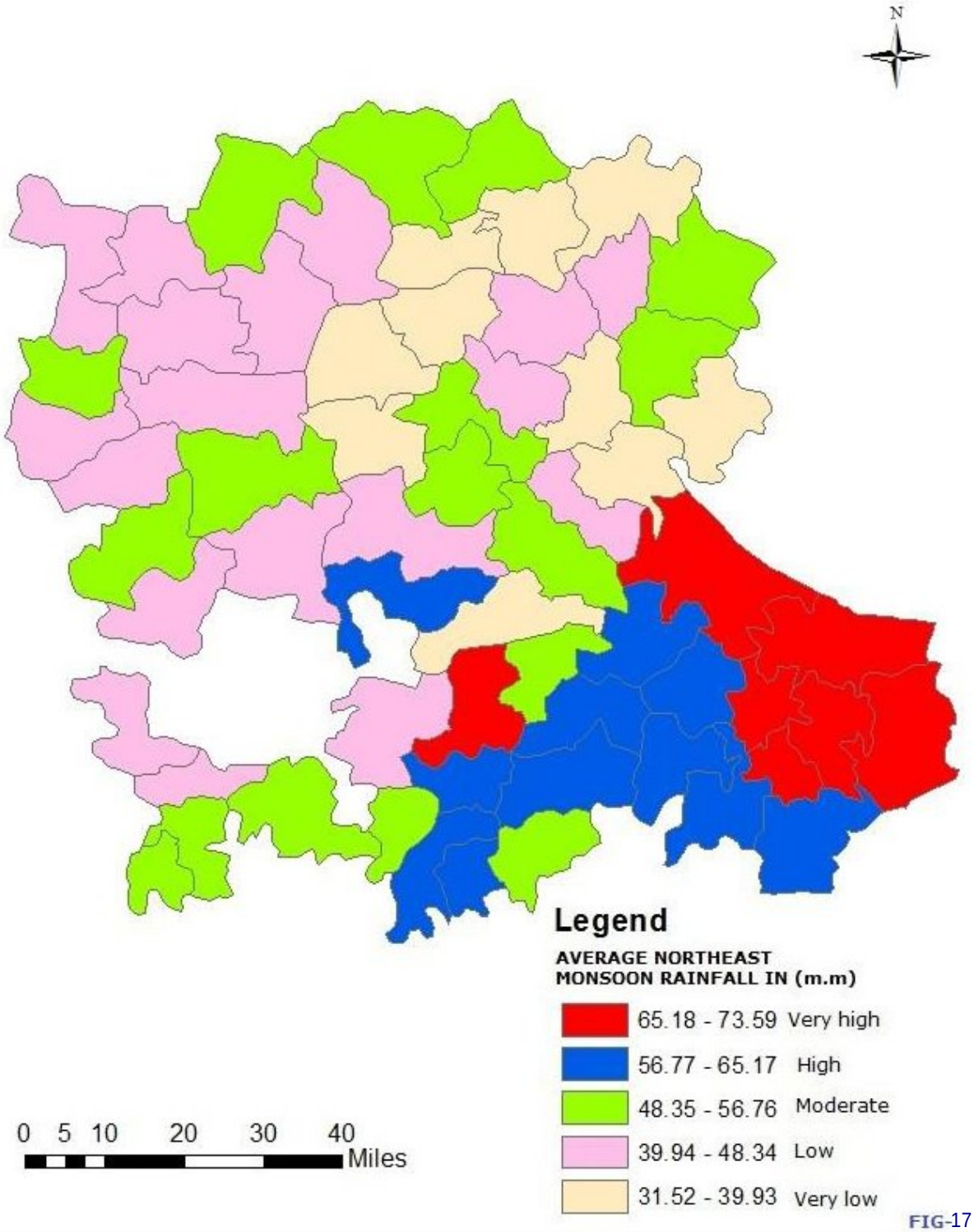


FIG-17 (B)

ANANTHAPUR DISTRICT

AVERAGE PERCENTAGE DEVIATION OF RAINFALL

1988-2012

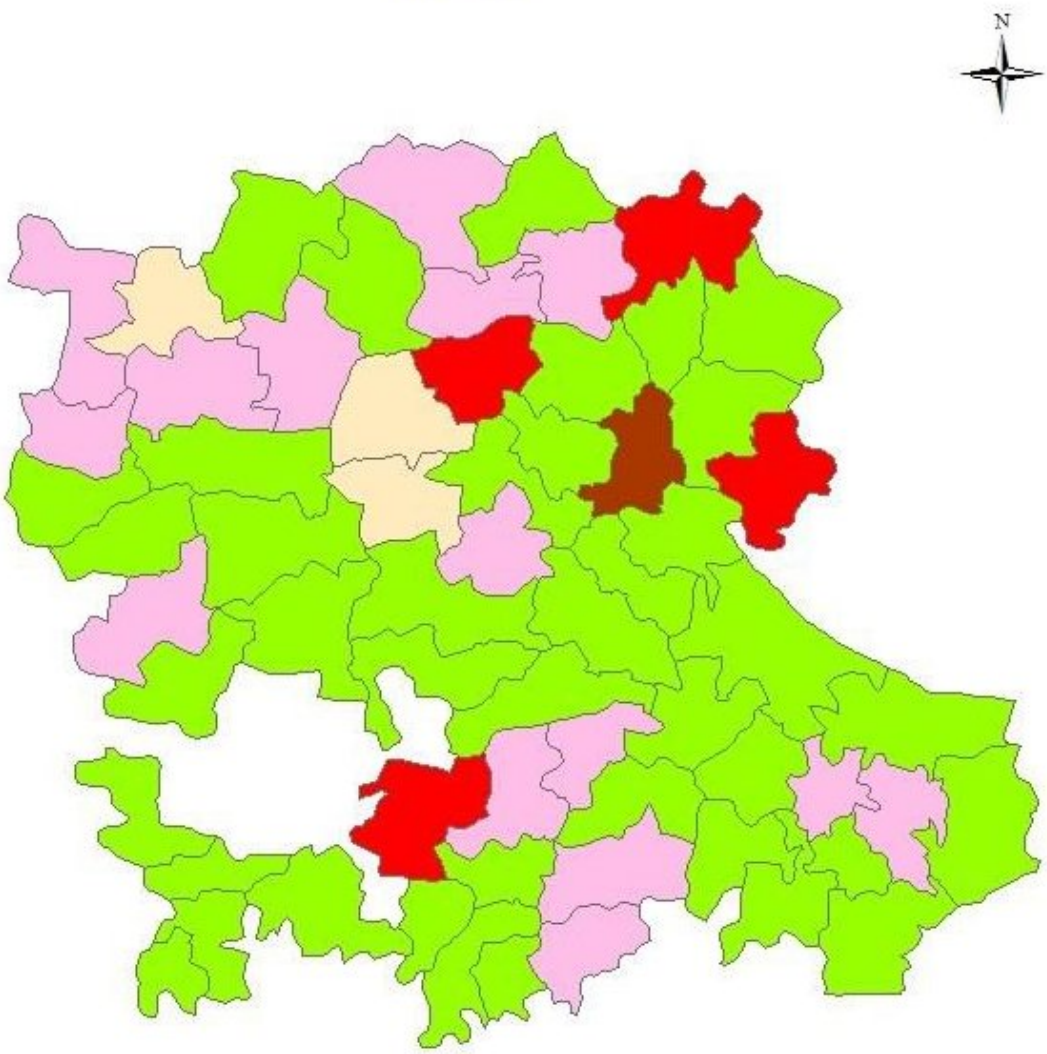


FIG-17 (C)

KURNOOL DISTRICT

Kurnool is located in the semiarid region where the rainfall is highly erratic. The district is located in the scarce rainfall region of the agroclimatic zone. The normal rainfall is 670mm. The rainfall is intensive and very often of a convective type. Seasonal variations in rainfall cause severe crop reduction. Scanty rainfall in one to two years within a span of five years resulted in drought like situations as shown in the below graph-8.

Graph-8

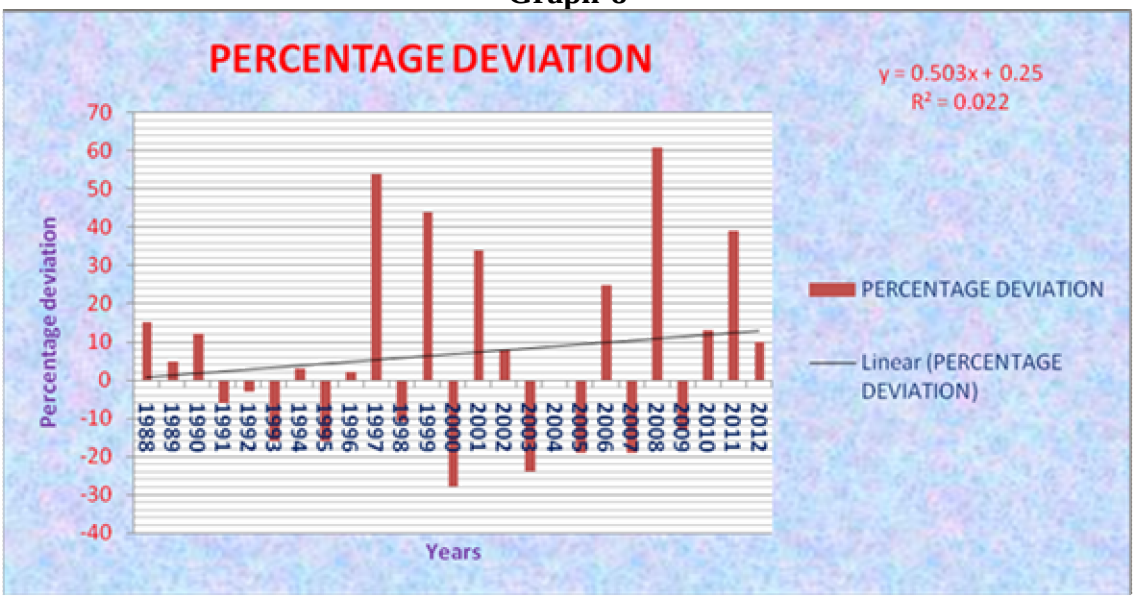


Table-3.15: Correlation between the Temperature and Rainfall during Southwest and Northeast Monsoon in Kurnool District

Seasons	Average Maximum Temperature	Average Minimum Temperature
Southwest Monsoon	-0.39404	-0.21505
Northeast Monsoon	0.315915	0.319883

The above table-3.15 represents the correlation between the Temperature (maximum and minimum) and rainfall (Southwest Monsoon season and Northeast Monsoon season).The correlation between Southwest Monsoon and average maximum temperature shows a negative correlation with -0.39404 which is insignificant, with an increase in rainfall, the temperature gradually comes down.During the Northeast Monsoon season both average maximum temperature and Average minimum temperatures showed positive correlation with +0.543 and +0.254 respectively. This district is located in the semi-arid region, where the rainfall is highly erratic and most of the rainfall is intensive and extreme partial and temporal variability.With seasonal variations in rainfall severe crop reductions are also caused by scanty rainfall.

Table-3.16: Months with actual average rainfall below its normal rainfall (mm) in Kurnool District for a period between 1988-2012

Months	Number of Years below normal rainfall	Range of Percentage Deviation from normal rainfall for deficit years (below normal)	Normal Rain fall
June	16	-77.4 to -7.6	77.2
July	14	-80.6 to -1.2	117.2
August	14	-69.7 to -2.0	135.0
September	14	-95.8 to -3.6	125.7
SWM	**14.5**	**-63.6 to -7.42**	**113.77**
October	14	-90.6 to -1.3	114.5
November	17	-100 to -9.9	27.6
December	22	-100 to -22.9	7.5
NEM	**17.66**	**-96.25 to -32.1**	**49.86**

The above table-3.16 shows the distribution of deficits rainfall below normal for both the seasons (Southwest and Northeast Monsoon) recorded in the district.Out of the25 years, it is observed below normal rainfall, was recorded for 15 years during Southwest Monsoon season and 18 years during Northeast Monsoon season.The range of percentage deviation from normal rainfall during Southwest Monsoon was between -63.6 to -7.42 and for Northeast Monsoon season it was -96.25 to -32.1.Both the seasons recorded maximum variation in rainfall.

The *Fig*-18Ashows the distribution of Southwest monsoon (for an average of 25 years) for all the mandals of Kurnool district. Very high rainfall during this season was observed in the mandals of Atmakur, Velugodu, Bandiatmakur, Nandyal, Siruvel and Rudravaram. All these mandals are on a higher elevation and closer to reserve forests. The mandals which received high rainfall are closer to the very high rainfall received mandals. They are Kothapalli, Pagidyala, Jupadu Bangalow, Midthur, Gadivemula, Mahanandi and Allagadda. The central part of the district received moderate to low rainfall. The mandals which received very low rainfall during the Southwest monsoon season lies to the western part of the district. The mandals which fall under this category are Kowthalam, Holagonda, Halaharvi, Chippagiri and Maddikera.

The *Fig*-18B is related to the Northeast monsoon season (average rainfall that was recorded between the years 1988 - 2012). Very high to high rainfall was observed in Rudravaram, Allagadda, Nandyal, Kolimigundla. The mandals such as Peapally, Owk, Bethamcherla, Banganapalli, Koilakuntla, Bandiatmakur, Atmakur, Chippagiri, Alur and Adoni have received high rainfall. Moderate to low rainfall was recorded in almost all the mandals in the Central and Southeastern part of the district. Very low rainfall during this season was found in Kodumur, Pagidyala, Pamulapadu and Gadivemula.

The *Fig*-18C shows the average percentage deviation of rainfall in the district. Very high percentage deviation was found in Kowthalam, Peddakadabur and Gospadu mandals. The high percentage deviation was found in Kothapalli, Pamulapadu, Koilakuntla Kallur, Devanakonda and Juggal. Except for Chippagiri, Dhone and Orvakal where very low percentage deviation was observed, the rest of the mandals in the district showed moderate to low percentage deviation of rainfall. These conditions indicate extreme spatial and temporal variability in rainfall resulting in dry spells and reduction in crop yields.

KURNOOL DISTRICT

AVERAGE SOUTHWEST MONSOON RAINFALL

1988-2012

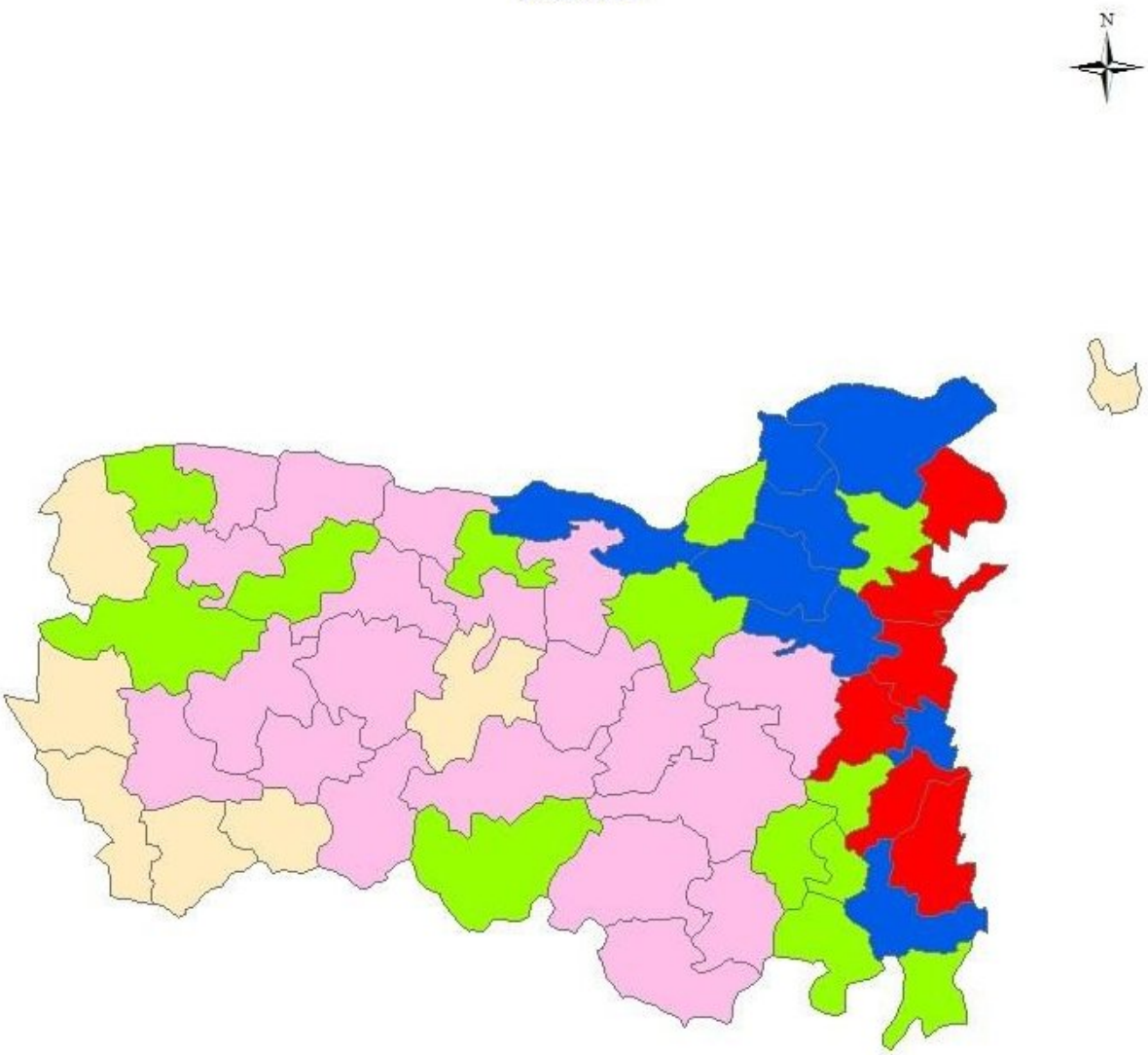


FIG- 18 (A)

KURNOOL DISTRICT

AVERAGE NORTHEAST MONSOON RAINFALL

1988-2012

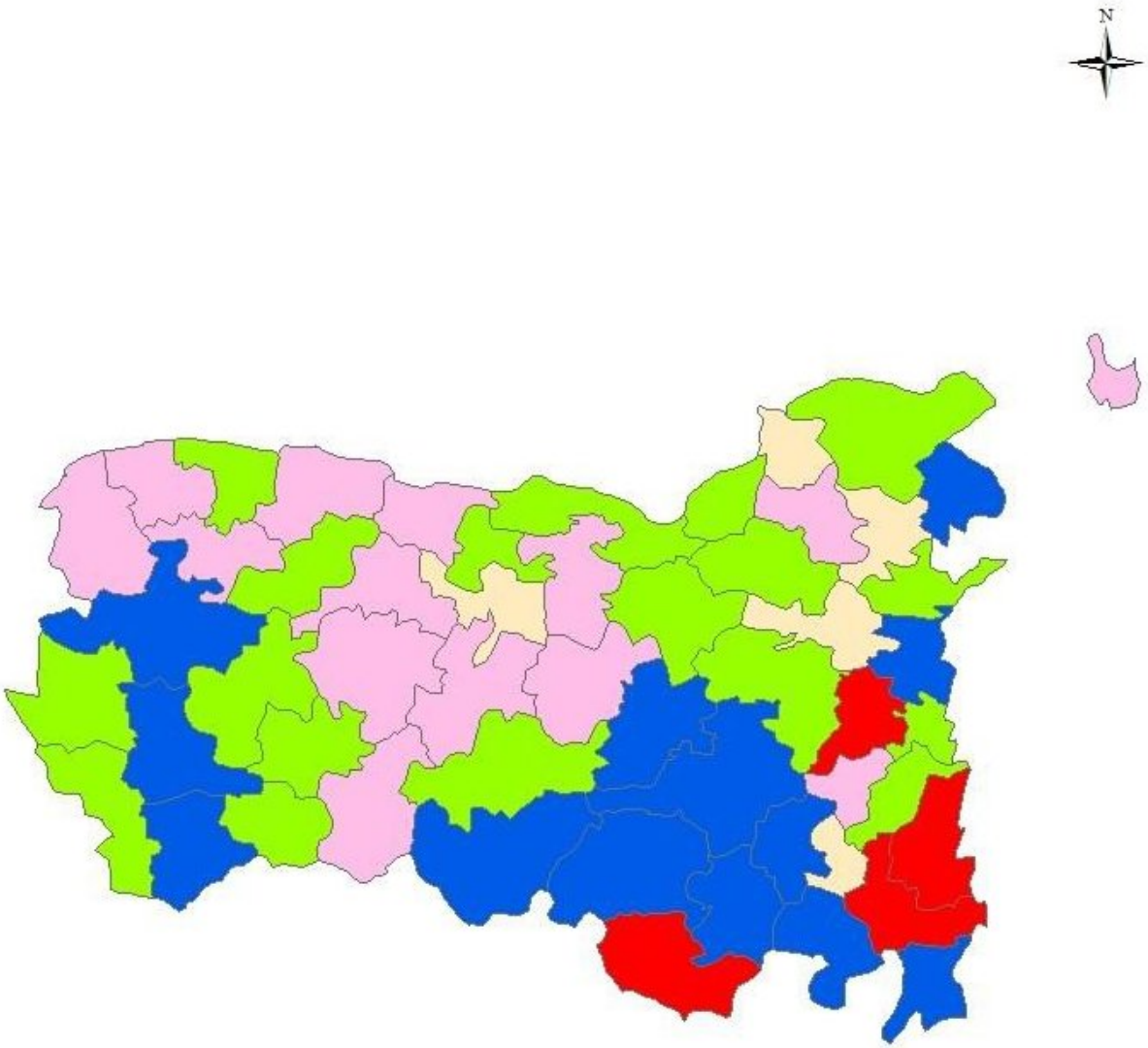


FIG-18 (B)

KURNOOL DISTRICT

AVERAGE PERCENTAGE DEVIATION OF RAINFALL

1988-2012

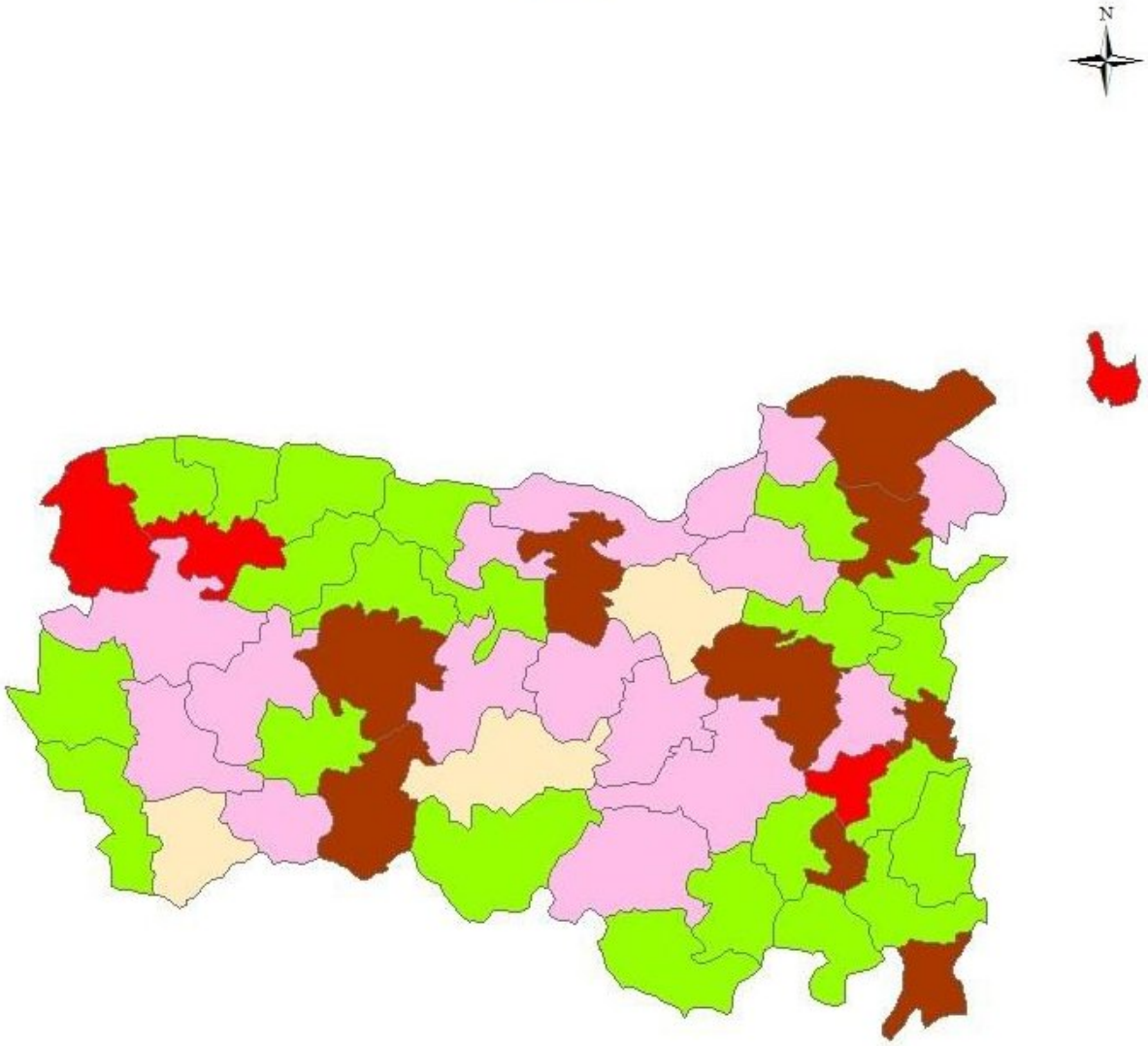


FIG 18 (C)

CHAPTER-IV
IMPACT OF RAINFALL ON CROP YIELD

IMPACT OF RAINFALL ON CROP YIELD

In the ambience of drastic global climatic changes, the inter relationship between the quantum of rainfall and the crop yield is an incontestable reality.Crop yield is largely affected by regional climatic variations based on fluctuating amounts of rainfall and an increase in maximum and minimum temperatures.It is surprising that even with so much of technological growth; agricultural yield still largely depends on good rainfall and monsoons.Because of the variability of climate, more intense and longer droughts have been observed over large areas since three of four decades, particularly in the tropics and sub-tropics.Further crop yield is largely dependent on the endowment of natural resources and environmental conditions of soil and climate.

It is also observed that the effect of climate change on crop yield generally ends up affecting food security and threatening the livelihood activities on which majority of the population depends on.Climate change can affect crop yields both positively and negatively.It also indirectly regulates the types of crops that can be grown in particular areas, by impacting agricultural inputs such as water for irrigation, the amount of solar radiation that affect plant growth as also the control of pests and insects.As is well known in India the agricultural sector represents 35% of its Gross National Product (GNP) and because of this it plays a very significant role in the country's development.Food grain production quadrupled after the country got independent because of better agricultural practices.A lot of research has been conducted by the Indian Agricultural Research Institute (IARI) to examine the susceptibility of crop yield to climate change, with the goal of ascertaining differences in climate change impacts on agriculture be region and by crop.A variety of crop growth models were used by scientists at IARI to analyse climate impacts on India's primary crops like Wheat and rice, and other crops such as sorghum and maize.Their findings indicated that changes in variables like temperature, Co2 levels, rainfall and solar radiation could both increase and decrease crop yield with changes in climate, so they also studied the interaction of these effects.The study also considered impacts on rain-fed versus irrigated crops.

India being a highly sanative rain-fed agricultural country and thanks to Norman Borlaug has ushered in green revolution and is on the threshold of Green Revolution 2, 70% of population continue to be poor.Food shortage is primarily due to insufficient production of food grains, despite best efforts of enhance the same.The causes are not far to seek, they are unfavourable weather conditions and socio-economic constraints which together stand in the way of successful application of new farm technology which will accelerate farm production.In most of the states in India agricultural scientists and farmers have responded to the challenges posed by continued food shortage

India ranks 1st amongst the rainfed agricultural countries in terms of quantity and qualitative value as well, in production.66% acreage of cropping falling in rain fed region.Rain fed agriculture supports 40% of the national food basket amounting to 55%

of Rice, 91% of Coarse Grains, 90% Pluses, 85% of Oil Seeds and 65% of Cotton.These areas have rainfall of 400mm to 1000mm which are unevenly spread out, resulting in an erratic picture of the agrarian scenario.As a consequence of this erratic scenario food production often reduced.Even if we go a step further and say that the climate change adversely affects rainfall and agriculture than any other sector. To study these factors which affect agriculture a proper prospective policy is the need of the hour.

The level of agricultural productivity, as the concept means the degree to which the economic cultural and organizational variables are able to exploit the a-biotic resources of the area for agricultural production (Singh, 1979).The spatial variation in physical output from the soils is the result partly of natural circumstances and partly of human manipulations of the land resources.The regional differences in yield per unit area indicate the magnitude and direction of the interplay of a multitude of factors.The level of agricultural productivity is a dynamic concept, as any modification in physical factors and improvement in nonphysical bases of farming affect agricultural production per hectare.

In the state of Andhra Pradesh majority of the population depend on agriculture.Various studies indicate that there is a correlation between crop yield and rainfall variability. Added to climatic aberrations, various agrarian policies of the state government, like free power supply, free seeds and pesticides, easy loans and minimum prices for the crops also indirectly affect different crop yields.In the state, as two thirds area comes under rain-fed agriculture, in impact of rainfall on crop yield is quite significant.Crop production can be effectively stabilized and sustain only if the limited water resource is effectively used.

There are several natural and cultural factors that directly influence crop yield and the most crucial natural factor that helps in increased crop production is the availability of sufficient quantities of moisture for proper growth of crops.In Andhra Pradesh because weather conditions are erratic, measuring the amount of moisture available at various locations becomes essential. Different regions in the state exhibit different geo-environmental conditions. There are plateaus, Ghats, Coastal Plains, Arid Zones and Wet areas that respond differently in terms of crop yields.It is because of the erratic occurrence of rainfall that a region experiences either drought or floods.So a study of the occurrence of rainfall during the monsoon and non-monsoon season and also throughout the year helps in accessing the effect of rainfall on the crop yield of a region especially in the case of dry lands or rain-fed agriculture.

The climate of the state can be divided into two types (a) Tropical rainy and (b) Hot steppe. In the first type the mean daily temperature for the coldest month is above 18^0C and the annual rainfall less than 250 cm.Most of the rainfall occurs during the Southwest monsoon.In the second region, the mean annual temperature goes above 18^0C. Hence the summer spell is quite hot and dry and this is followed by the monsoon season.

In Andhra Pradesh, in the coastal area, however a great amount of rainfall occurs outside the normal stipulated period of rainfall. The rainfall is less in Western Rayalaseema (about 60cm) compared to the North and North-eastern part of the state which receives more than 140cm of rain. The state receives a lot of rainfall even during the Northeast monsoon period except in the Telangana region. In the Southern Coastal belt there is rainfall even from October to December.In the coastal district of Visakhapatnam, the unbroken range of Eastern Ghats lying in the neighbourhood exerts a lot of influence on rainfall and its distribution. They stop the rain bearing Eastern winds which blow because of depressions in the Bay of Bengal, during the Southwest monsoon.The rainfall in the state increases inland towards West.It is approximately 100 cm near the Coast and increases to about 140 cm along parts of the Northern Boundary and in the remaining parts of the State, the rainfall decreases as we go inland.

This chapter deals with rainfall variability and its impact on crop production in the selected mandals of various agroclimatic zones.Using the following equation, the multiple linear regression analysis was carried out to ascertain the impact of rainfall, human labour and fertilizer input on crop yields.

EQUATION

$Y = f(F, HL, AR, Max.\ Temp, Min.\ Temp)$

Y = Yield in kg per Hectare

F = Fertilizers in kg per Hectare

HL = Human labor hour per Hectare

AR = Actual Rainfall (mm)

Max. Temp = Maximum Temperature in ^0C

Min. Temp = Minimum Temperature in ^0C

Further, an attempt has also been made to study the impact of climate factors on the Agricultural GDP and in turn on the prices. This study was carried out for a period of 25 years between 1988-2012. Based in the impact of the productivity, the effect of GDP was carried out using Ordinary Least Square model (OLS). The OLS model was used to estimate the R2 values of the major crops along with two data sets.

1. Prices, Rainfall and Production
2. GDP, Prices, Rainfall and Production

TELANGANA REGION

Four districts of Telangana were selected to ascertain the coefficient of variance as mentioned in the earlier chapter.From each district again four mandals were chosen for a detailed study of the correlation between rainfall and crop yield.

KHAMMAM DISTRICT

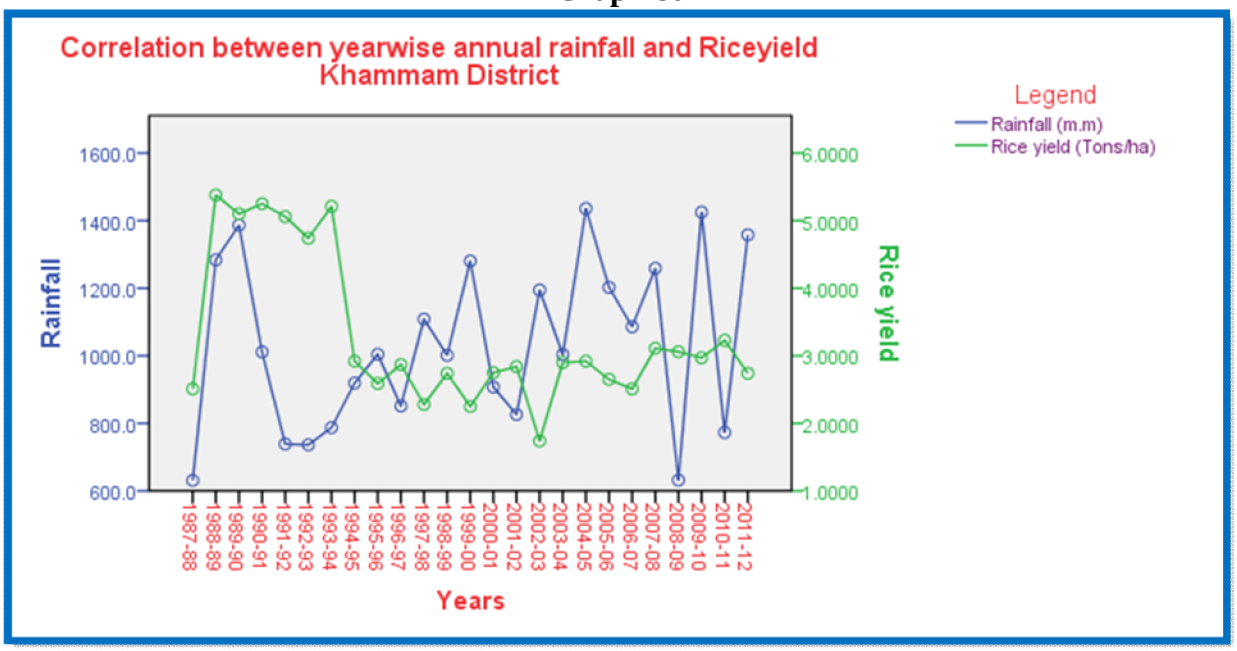
Khammam district falls under the central Telangana zone. For our study six mandals of the district were selected based on the coefficient of variance. The six mandals are Nelakondapalle, Mudigonda, Wyra, Chinthakani, Bonakal and Madhira. The table below represents the annual rainfall, Co-efficient of variance, percentage deviation and R^2 values.

Table-4.1

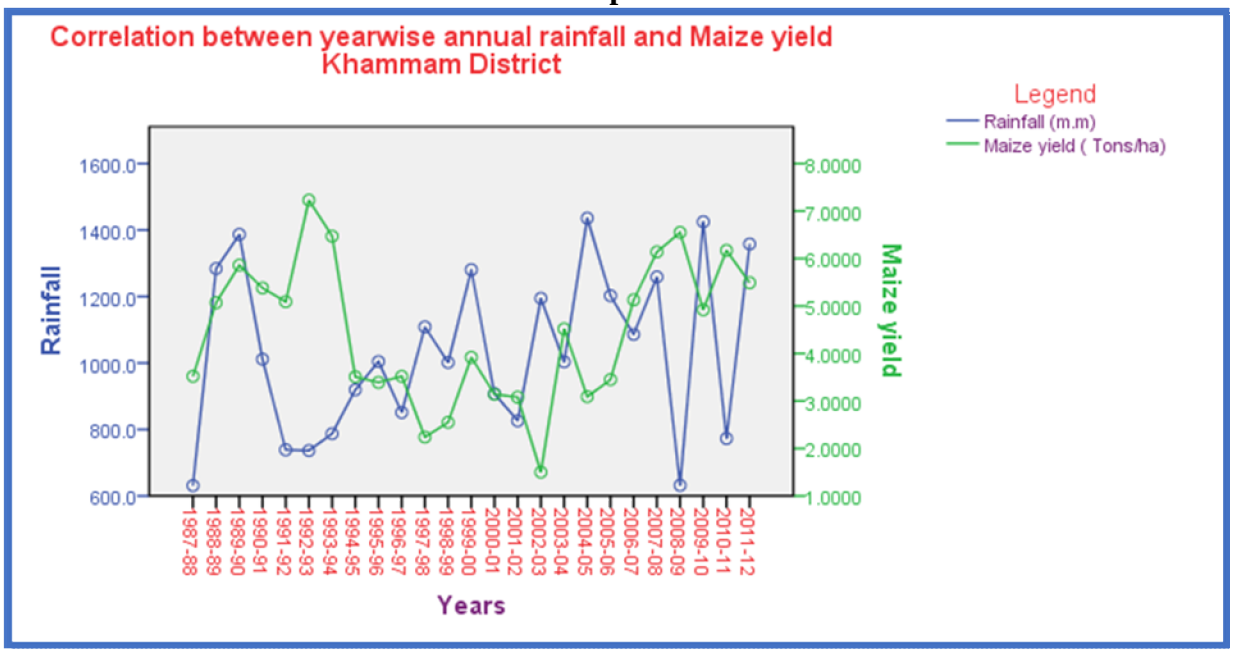
MANDALS CHOSEN FOR DETAILED ANALYSIS IN KHAMMAM DISTRICT						
S.No.	**Mandals**	**Annual Rainfall**	**Normal Rainfall**	**CoV**	**Percentage Deviation**	**R^2 Values**
	CENTRAL TELANGANA ZONE					
1	NELAKONDAPALLE	973.1	992.0	26.0	-1.9	0.06
2	MUDIGONDA	901.3	989.8	33.3	-8.9	0.02
3	CHINTHAKANI	910.5	988.2	29.5	-7.9	0.06
4	WYRA	760.7	1086.0	70.9	-29.9	0.09
5	BONAKAL	936.3	989.5	31.0	-5.4	0.04
6	MADHIRA	866.5	969.8	48.9	-10.6	0.00

Graphs (9a) to (9d) show the correlation between the major crop yields and annual rainfall.For Rice, it can be seen that there is no direct correlation between rainfall and crop yield.

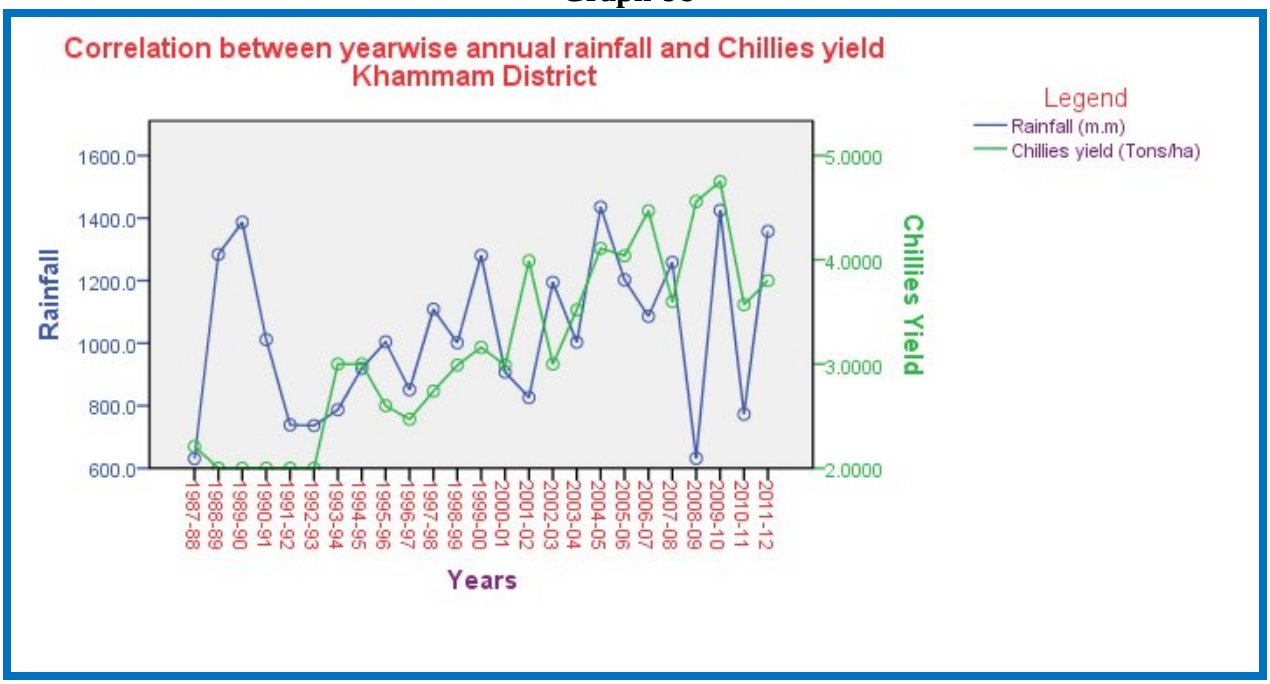
Graph-9a



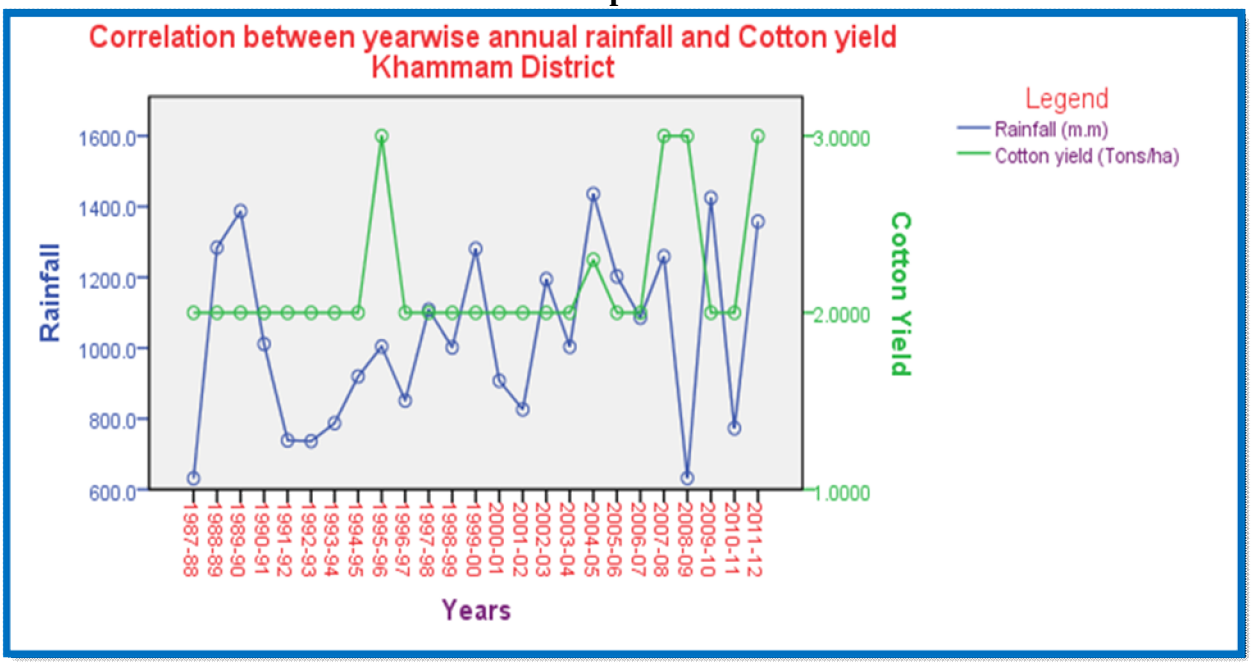
Graph-9b



Graph-9c



Graph-9d



From this it can be inferred that other sources of water may have been used or the yield for crop could be correlated by including other parameters like fertilizer input, average of crop being sown each year.The correlation is similar as far as the other crops Maize, Cotton and Chillies are concerned.The regression values for the four crops for the period 1988 – 2012 is shown in the following table-4.2.

Table-4.2 Regression Values for the four crops forthe period 1988 – 2012 in Khammam District

Cases	Constant	Act-avg	Max-tem	Min-tem	Fertilizers	Human labour	R^2
Coefficient values for Rice							
Case 1	423.296	-.080	-8.149	-370.427	8.631	6.260	.623
Case 2	194.102	-.074	###	-372.427	8.622	6.264	.623
Case 3	138.424	###	###	-373.959	8.625	6.276	.622
Case 4	-7477.766	###	###	###	7.551	5.889	.597
Coefficient values for Maize							
Case 1	29184.987	-3.031	-685.200	-228.784	10.012	.182	.263
Case 2	29629.719	-3.030	-689.107	-225.771	9.780	###	.263
Case 3	26177.685	-3.069	-740.134	###	9.693	###	.257
Case 4	2311.661	-2.214	###	###	7.052	###	.198
Coefficient values for Chillies							
Case 1	172.080	.594	381.677	-349.258	1.914	-3.370	.666
Case 2	-190.791	.832	449.618	-353.103	###	-4.189	.660
Case 3	-5654.234	.754	366.974	###	###	-4.100	.623
Case 4	-1169.258	###	267.457	###	###	-4.483	.583
Coefficient values for Cotton							
Case 1	-962.257	-.296	8.532	87.017	2.378	-.064	.345
Case 2	-1072.367	-.302	8.793	87.487	2.443	###	.345
Case 3	-845.574	-.311	###	90.154	2.469	###	.345
Case 4	1222.378	-.306	###	###	2.515	###	.330

Coefficient values were calculated using the variables of average rainfall maximum and minimum temperature, fertilizers and human labour.For Rice the R^2 value is 62% when all the parameters are taken into consideration.The weather parameters of rainfall and temperature have a negative impact on crop yield unlike fertilizers and human labour which showed a positive impact.For Maize, the R^2 value is 26.4% when all the parameters are taken into consideration.All the parameters have a negative impact on crop yield except fertilizers.For Chillies the R^2 value is 66.6% when all the parameters are taken into consideration.Minimum temperature and human labour showed negative impact on crop yield.In the case of Cotton, the R^2 value is 34.7%.Rainfall had a negative impact on crop yield, all the other parameters showed a positive impact.

Table-4.3Regression Values for Rice in Kharif and Rabi Seasons in Khammam District

Cases	Constant	Act-avg	Max-tem	Min-tem	Fertilizers	Human labour	R^2
Coefficient values for Rice Kharif Madhira Mandal							
Case 1	-10339.750	1.382	100.266	-200.967	9.410	8.716	.377
Case 2	-9686.358	###	87.988	-238.856	10.006	9.029	.374
Case 3	-7420.295	###	###	-214.564	10.007	8.954	.370
Case 4	-10629.309	###	###	###	8.370	8.463	.358
Coefficient values for Rice Rabi Madhira Mandal							
Case 1	-17465.264	.378	108.749	185.770	8.173	6.615	.476
Case 2	-17464.591	###	109.279	183.896	8.196	6.632	.476
Case 3	-14007.248	###	149.171	###	7.767	6.491	.470
Case 4	-8756.359	###	###	###	8.275	6.345	.457
Coefficient values for Rice Kharif Bonakal Mandal							
Case 1	1119.019	.137	11.426	-401.722	8.505	5.226	.692
Case 2	1189.225	###	8.253	-400.931	8.529	5.236	.692
Case 3	1391.583	###	###	-398.686	8.534	5.236	.692
Case 4	-5603.019	###	###	###	6.320	4.794	.651
Coefficient values for Rice Rabi Bonakal Mandal							
Case 1	-10159.077	5.749	118.190	98.717	3.915	3.875	.548
Case 2	-8360.297	5.750	138.231	###	3.790	3.834	.546
Case 3	-3699.264	5.654	###	###	4.352	3.847	.534
Case 4	-4251.906	###	###	###	5.022	4.085	.515
Coefficient values for Rice Kharif Wyra Mandal							
Case 1	836.065	1.452	9.168	-367.685	7.461	5.572	.703
Case 2	1060.959	1.440	###	-365.061	7.464	5.573	.703
Case 3	1317.062	###	###	-370.532	7.475	5.559	.696
Case 4	-5540.743	###	###	###	6.016	5.093	.657
Coefficient values for Rice Rabi Wyra Mandal							
Case 1	-12531.315	4.207	97.584	93.973	6.407	5.644	.687
Case 2	-10855.755	4.301	117.440	###	6.295	5.607	.686
Case 3	-6856.716	3.994	###	###	6.745	5.601	.677
Case 4	-6950.367	###	###	###	6.888	5.666	.668
Coefficient values for Rice Kharif Chinthakani Mandal							
Case 1	4302.544	.150	-82.481	-381.332	8.447	4.711	.684
Case 2	4359.776	###	-85.479	-380.690	8.493	4.718	.684
Case 3	2251.559	###	###	-400.356	8.372	4.690	.680
Case 4	-5285.155	###	###	###	6.745	4.370	.635
Coefficient values for Rice Rabi Chinthakani Mandal							
Case 1	-13328.540	4.998	95.376	96.071	6.949	6.148	.648
Case 2	-11692.635	5.003	118.299	###	6.785	6.127	.646
Case 3	-7618.100	4.529	###	###	7.316	6.015	.638

Case 4	-7803.236	###	###	###	7.649	6.064	.629
Coefficient values for Rice Kharif Mudigonda Mandal							
Case 1	1518.743	1.662	6.878	-383.076	7.393	5.376	.647
Case 2	1658.915	1.580	###	-380.141	7.414	5.380	.647
Case 3	1118.340	###	###	-357.326	7.684	5.407	.644
Case 4	-5231.377	###	###	###	5.974	4.893	.610
Coefficient values for Rice Rabi Mudigonda Mandal							
Case 1	-15464.598	11.550	177.647	78.574	6.294	6.082	.617
Case 2	-14073.482	11.830	196.519	###	6.109	6.035	.616
Case 3	-7470.614	9.317	###	###	7.105	5.974	.594
Case 4	-8175.442	###	###	###	7.983	6.250	.573
Coefficient values for Rice Kharif Nelakondapalli Mandal							
Case 1	380.123	.663	15.967	-402.341	8.520	6.088	.604
Case 2	764.526	.551	###	-397.586	8.540	6.092	.604
Case 3	722.173	###	###	-394.264	8.567	6.104	.604
Case 4	-5857.184	###	###	###	6.175	5.447	.565
Coefficient values for Rice Rabi Nelakondapalli Mandal							
Case 1	-13487.430	5.094	114.219	113.265	6.668	5.291	.656
Case 2	-11469.415	5.533	141.425	###	6.385	5.221	.654
Case 3	-11356.729	###	118.287	###	7.222	5.503	.644
Case 4	-7318.587	###	###	###	7.714	5.451	.636

The mandal wise description of Rice crop in the Kharif and Rabi season using various climatic parameters, fertilizers and human labour is given in the table-4.3.In the Madhira mandal, R^2 is 37.7% and rabi is 47.6%. All the parameters have a positive impact on the yield except maximum temperature.This indicates that as the rainfall increases, the yield also increases.

In Bonakal mandal, in the Kharif season the coefficient value is 69.2% and all the parameters except minimum temperature have a positive impact on the yield.In the Rabi season, the coefficient value is 54.5% and all the parameters except minimum temperature have a positive impact.This indicates that all parameters are required to increase crop yield.

For the Wyra mandal, the coefficient value is 70.3% in the Kharif season.Here also except minimum temperature, all other parameters have a positive impact and, in the Rabi, season the R^2 value is 68.7% and all the parameters have a positive impact on the crop yield.The climatic as well as fertilizer and human labour have a positive correlation and impact on crop yield.

In Chinthakani mandal, the coefficient value for Kharif season is 68%. The minimum temperatures have shown negative impact on the crop yield.Even rainfall

showed an insignificant impact on the crop yield.Both human labour and fertilizers showed positive impact.In the Rabi season the coefficient value is 64.8%.All the identified parameters have shown a positive relationship.

In Mudigonda mandal the coefficient value for Rice crop in Kharif season is 64.5%.All the variables have a positive impact on the Rice crop yield except minimum temperature. In Rabi season the coefficient value is 61.7% and all the parameters have a positive impact in the crop yield.

In Nelakondapalli the coefficient value in the Kharif season showed 60.4%, here also except minimum temperature all the other variables have a positive impact on the crop yield.During the Rabi season the R^2 value showed 65.6% and all the variables have positive impact on the Rice crop yield.

Table-4.4 Findings of Fitted Models through Ordinary Least Square Method – Khammam District

Commodities	Prices, Rainfall, Production			GDP, Prices, Rainfall Production	
	Observations	Multiple R	R Square	Multiple R	R Square
Rice	25	0.713	0.508	0.898	0.806
Maize	25	0.942	0.888	0.937	0.879
Chillies	25	0.620	0.385	0.945	0.892
Cotton	25	0.853	0.728	0.956	0.914

The above table-4.4 shows the finding of fitted models through ordinary least square method (OLS). The OLS model was used to estimate the R-square values and its significance was computed for 2 datasets. (1) Prices, Rainfall and Production (2) GDP, Prices, Rainfall and Production. The finding indicates that R-square values without GDP varied from 0.88 to 0.39 for the four crops whereas when the GDP values are considered the R-square values are from 0.91 to 0.81.It is concluded that both production and agricultural GDP are affected to a great extent by climate variation in the district.

MAHBUBNAGAR DISTRICT

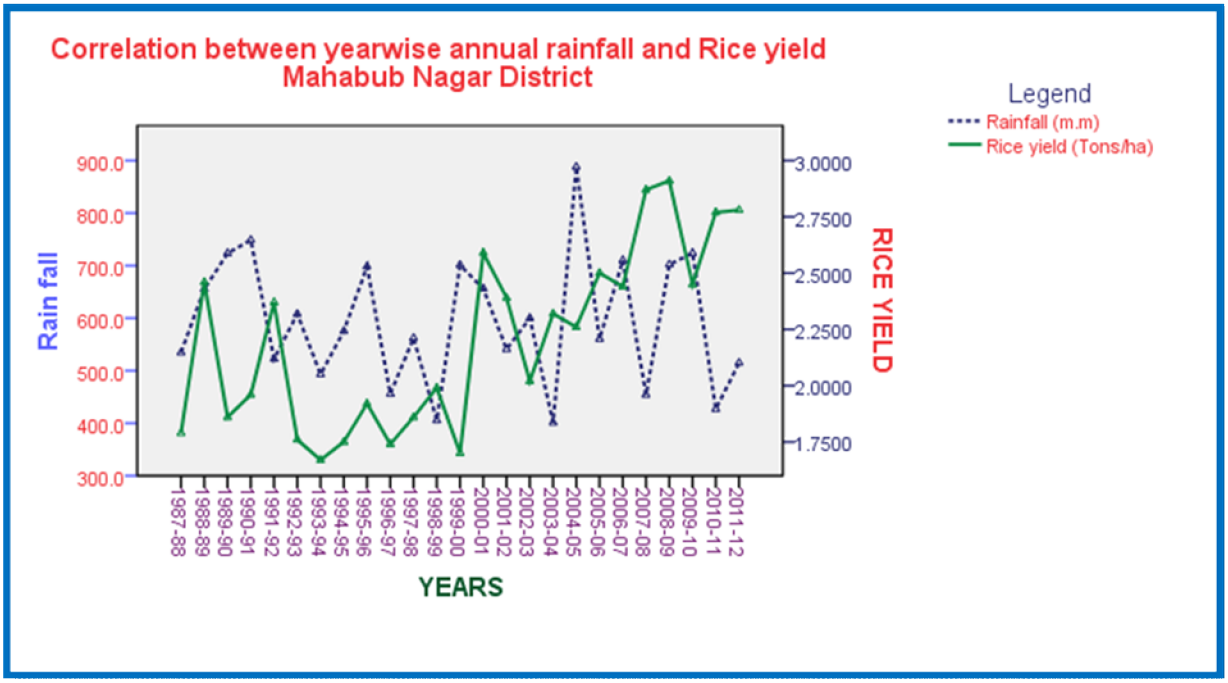
Mahbubnagar district falls under South Telangana zone.Four mandals which were selected for detailed study here recorded low rainfall; hence they fall under scarce rainfall agroclimatic zone.The coefficient of variance for all the 64 mandals of the district was calculated and the details are shown in the table-4.5.

Table-4.5

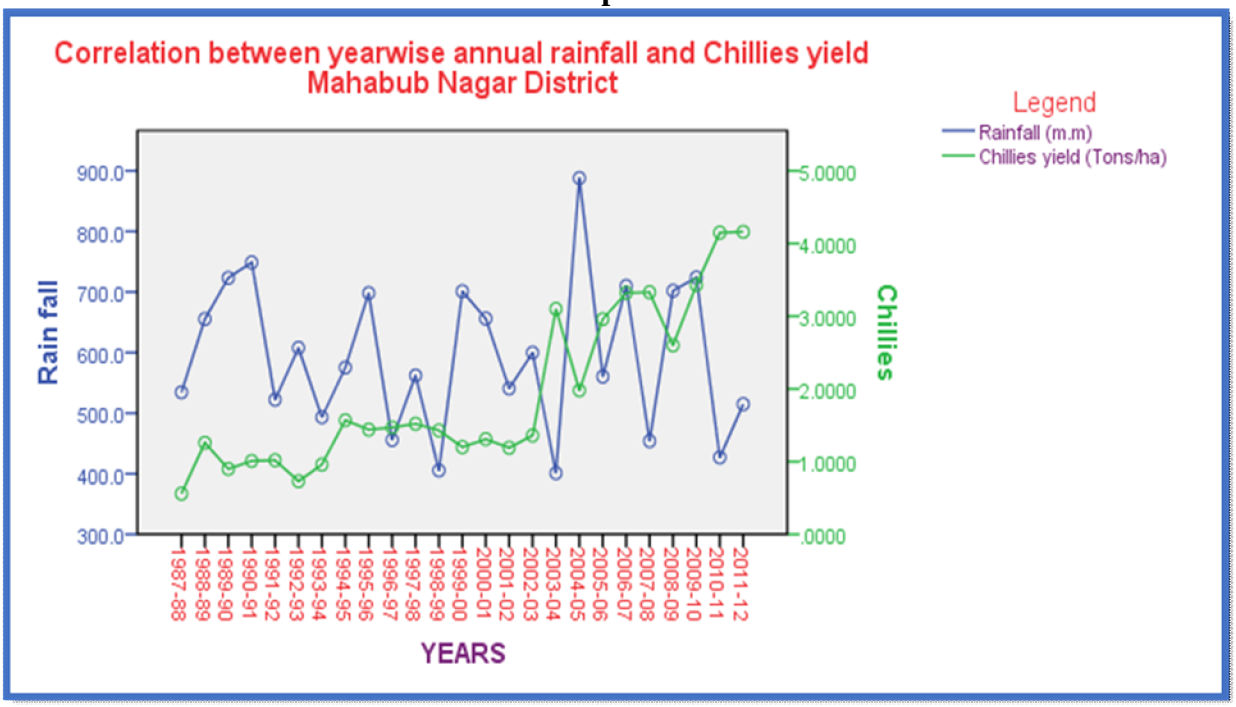
MANDALS CHOSEN FOR DETAILED ANALYSIS IN MAHABUBNAGAR DISTRICT						
S.No.	**Mandals**	**Annual Rainfall**	**Normal Rainfall**	**CoV**	**Percentage Deviation**	**R^2 Values**
	SCARCES RAINFALL ZONE					
1	WADDEPALLE	588.0	544.3	27.9	8.0	0.01
2	ITIKYAL	601.8	532.5	33.4	13.0	0.00
3	MANOPADU	568.0	482.1	31.3	17.8	0.04
4	ALAMPUR	618.1	584.8	27.7	5.7	0.00
5	PEBBAIR	598.6	536.0	29.4	11.7	0.01

The mandals with low coefficient values were selected for detailed study.These mandals are Waddepalli, Itikyal, Manopadu, Alampur and Pebbair. In order to understand the correlation between the agricultural productivity and rainfall patterns in the district, four crops such as Rice, Chillies, Groundnut and cotton – this forms the major crops of the districts, which were chosen for analysis.The correlation between annual rainfall and crop yield are shown for the four crops in the graphs (graph (10-a) to graph (10-d)).For Rice as can be seen in (10-a) there is no direct correlation between the quantum of rainfall and the yield of the crop.

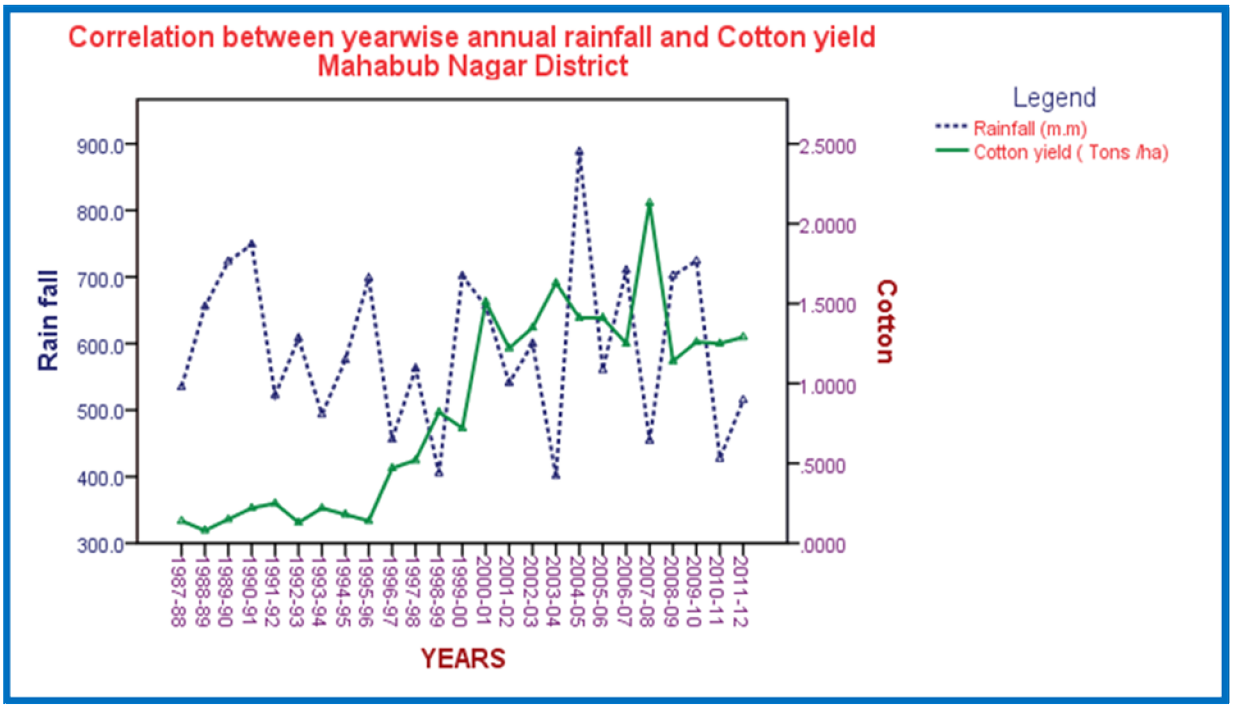
Graph-10a



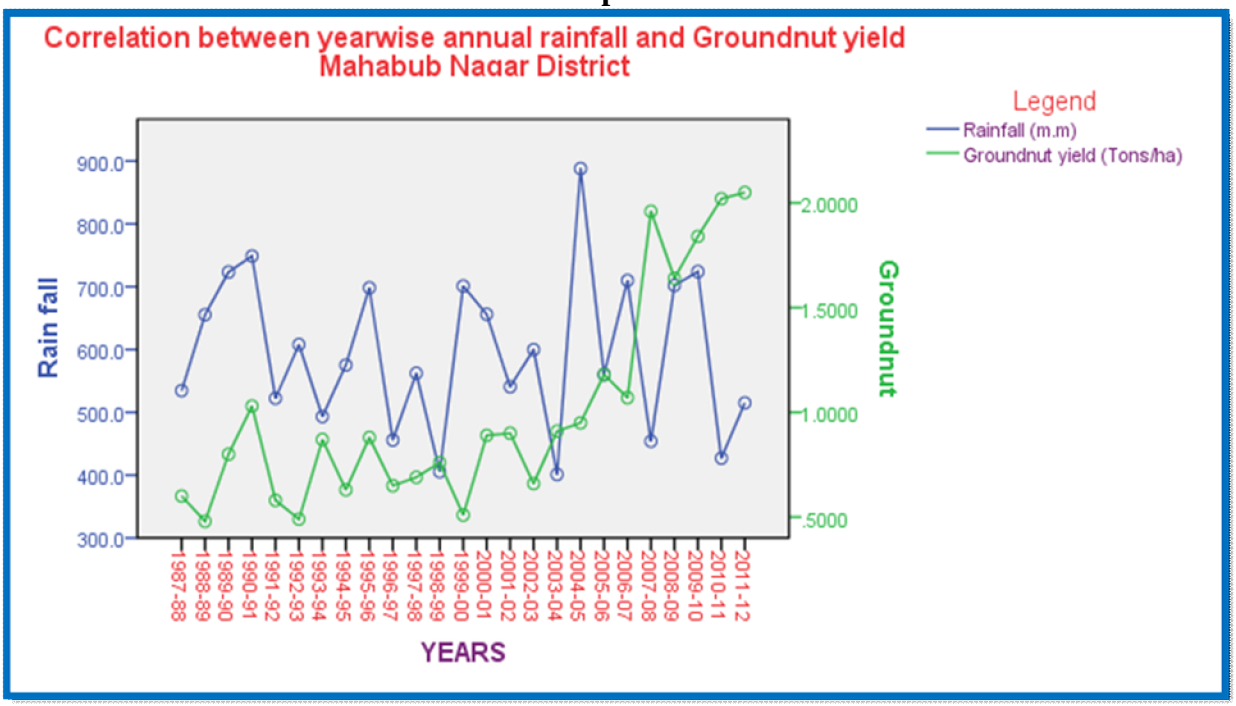
Graph-10b



Graph-10c



Graph-10d



It is inferred that other sources of water may be used or the yield for the crop may be correlated by including other parameters like fertilizer inputs, other sources of water,

pesticide and the average of crop being sown each year. Similarly, the graph for the crop groundnut depicts a direct relation between the annual rainfall and yield, a decrease in rainfall has led to decrease in the crop yield.For the Chillies and Cotton crops, no correlation exists between the rainfall pattern and the crop yield.It can be seen that Rice, Cotton and Chillies have a mixed response to rainfall and so other parameters must be considered to establish correlation like fertilizers, pesticides, micro nutrients etc.

When the climatic parameters (rainfall and temperature) were analysed exhaustively it was ascertained that complex changes affected crop productivity in the district.The four crops of the district were taken for computing R^2 values which is highlighted in the table-4.6.

Table-4.6 Regression Values for the four crops for the period 1988 – 2012 in Mahabubnagar District

Cases	Constant	Act-avg	Max-tem	Min-tem	Fertilizers	Humanlabour	R^2
Coefficient values for Rice							
Case 1	355.448	0.205	381.831	-501.414	1.011	-0.722	0.657
Case 2	480.669	###	381.736	-501.351	1.011	-0.722	0.657
Case 3	-3682.351	0.182	485.570	-519.613	1.450	###	0.641
Case 4	1491.821	0.393	405.195	-542.375	###	-1.228	0.632
Coefficient values for Groundnut							
Case 1	2241.715	-0.021	271.143	-362.553	0.241	-2.618	0.586
Case 2	2230.247	###	271.042	-362.444	0.240	-2.618	0.586
Case 3	-1634.374	0.178	259.730	-359.034	12.163	###	0.494
Case 4	2165.039	-0.023	275.601	-363.172	###	-2.645	0.586
Coefficient values for Chillies							
Case 1	10292.621	-1.339	-322.356	-289.832	18.637	3.474	0.854
Case 2	9485.366	###	-322.574	-289.522	18.638	3.474	0.854
Case 3	18333.054	-1.133	-321.882	-451.314	15.477	###	0.818
Case 4	-18159.372	-0.037	1401.059	-1111.917	###	-2.345	0.503
Coefficient values for Cotton							
Case 1	5280.333	-0.374	-104.024	-187.567	8.546	0.620	0.769
Case 2	5052.943	###	-103.836	-187.708	8.544	0.619	0.769
Case 3	6651.319	-0.323	-103.420	-215.265	8.022	###	0.767
Case 4	-5378.997	0.309	639.563	-573.263	###	-2.709	0.544
Case 5	-18549.589	0.252	932.194	-546.892	###	###	0.471

In order to further assess the impact of other parameters like fertilizers, human labour hour on agricultural production in addition to climatic variables in the district; multiple regression equation has been used.The two seasons i.e. Kharif and Rabi Rice crop were considered to calculate the R^2 values for the five mandals of the district.

Table-4.7 Regression Values for Rice in Kharif and Rabi Seasons in Mahabubnagar District

Cases	Constant	Act-avg	Max-tem	Min-tem	Fertilizers	Humanlabour	R^2
Coefficient values for Rice Alampur Mandal Kharif							
Case 1	-8445.898	0.125	618.378	-528.174	1.343	0.577	0.670
Case 2	-8373.410	###	618.387	-528.163	1.342	0.577	0.670
Case 3	-5603.123	0.072	567.806	-536.808	0.815	###	0.663
Case 4	-6494.484	0.154	633.310	-570.081	###	-0.090	0.650
Coefficient values for Rice Alampur Mandal Rabi							
Case 1	-9971.871	0.146	643.823	-532.575	1.541	0.908	0.678
Case 2	-9886.812	###	643.823	-532.562	1.541	0.907	0.678
Case 3	-5761.370	0.071	568.913	-542.494	0.737	###	0.665
Case 4	-6794.484	0.154	633.310	-570.081	###	-0.090	0.650
Coefficient values for Rice Manapad MandalKharif							
Case 1	-9608.513	0.181	644.402	-531.332	1.407	0.873	0.679
Case 2	-9522.040	###	644.423	-531.332	1.407	0.873	0.679
Case 3	-5694.634	0.139	575.555	-540.338	0.628	###	0.667
Case 4	-7298.704	0.270	645.913	-561.236	###	0.040	0.657
Coefficient values for Rice Manapad MandalRabi							
Case 1	-8749.827	0.165	622.311	-528.817	1.185	0.551	0.671
Case 2	-8671.192	###	622.336	-528.819	1.185	0.551	0.671
Case 3	-6132.209	0.136	576.209	-536.597	0.678	###	0.665
Case 4	-7598.704	0.270	645.913	-561.236	###	0.040	0.657
Coefficient values for Rice Pebbair MandalKharif							
Case 1	-8163.604	0.145	620.572	-551.391	1.349	0.723	0.677
Case 2	-8084.746	###	620.558	-551.399	1.348	0.723	0.677
Case 3	-5152.128	0.171	562.632	-550.175	0.754	###	0.669
Case 4	-5070.405	0.200	599.397	-576.774	###	-0.256	0.654
Coefficient values for Rice Pebbair MandalRabi							
Case 1	-7800.098	0.134	602.903	-542.369	1.276	0.503	0.671
Case 2	-7727.428	###	602.892	-542.381	1.276	0.503	0.671
Case 3	-5621.949	0.159	563.094	-544.864	0.819	###	0.667
Case 4	-5370.405	0.200	599.397	-576.774	###	-0.256	0.654
Coefficient values for Rice Itkyal MandalKharif							
Case 1	-8017.672	0.038	633.772	-563.611	1.049	0.668	0.669
Case 2	-7998.272	###	633.797	-563.610	1.049	0.668	0.669
Case 3	-5193.127	0.003	570.737	-552.687	0.644	###	0.663
Case 4	-5150.119	0.040	600.371	-569.349	###	-0.275	0.649
Coefficient values for Rice Itkyal MandalRabi							
Case 1	-8442.523	0.023	629.246	-557.621	1.209	0.716	0.670
Case 2	-8430.985	###	629.264	-557.619	1.209	0.716	0.670

Case 3	-5493.127	0.003	570.737	-552.687	0.644	###	0.663
Case 4	-5201.640	0.039	593.316	-568.592	###	-0.302	0.650
Coefficient values for Rice Waddepalli MandalKharif							
Case 1	-11997.002	-3.204	319.280	161.365	2.449	-0.403	0.637
Case 2	-12233.021	###	319.280	161.365	2.449	-0.403	0.637
Case 3	-13175.846	-3.166	324.268	175.715	2.937	###	0.633
Case 4	-8450.764	-2.687	329.210	114.172	###	-1.716	0.569
Coefficient values for Rice Waddepalli MandalRabi							
Case 1	2025.822	2.370	84.616	-182.185	2.235	-0.505	0.421
Case 2	2042.413	###	84.616	-182.185	2.235	-0.505	0.421
Case 3	911.317	2.397	104.890	-205.823	2.838	###	0.416
Case 4	4712.721	3.168	25.473	-84.206	###	-1.792	0.368

For Alampur mandal the R^2 value in the Kharif season is 67.0% and, in the Rabi season the R^2 value is 67.8%, except for minimum temperature, other parameters have direct impact on the Rice crop yield. A similar sort of analysis was undertaken for Manapad, Pebbair, Itkyal and Waddepalli mandals and the results were shown in the table-4.7.In all these mandals, as far as the Kharif crop is concerned the rainfall, temperature, fertilizers and human labour show positive impact on the Rice crop yield.Further, in the Rabi season except for minimum temperature, all the other parameters have direct impact on the Rice crop yield.

Table-4.8 Findings of Fitted Models through Ordinary Least Square Method – Mahabubnagar District

Commodities	Prices, Rainfall, Production			GDP, Prices, Rainfall Production	
	Observations	Multiple R	R Square	Multiple R	R Square
Rice	25	0.642	0.412	0.904	0.817
Groundnut	25	0.552	0.305	0.935	0.873
Chillies	25	0.485	0.235	0.904	0.817
Cotton	25	0.555	0.308	0.903	0.815

To study the impact of weather variables on agricultural GDP an analysis was done by using ordinary least square model (OLS).This model was used to estimate the R^2 values and its significance was computed for 2 datasets.(1) Prices rainfall and Production (2) GDP, Prices rainfall and Production, the results were shown in the above table-4.8.The study showed a very high impact of rainfall over production and prices for the crops of the district, when the second set was considered.

NALGONDA DISTRICT

The coefficient of variance (COV) for all the 59 mandals of Nalgonda district was calculated. Four mandals were selected based on high and low coefficient of variance values.The following table gives a detailed account of these selected mandals.

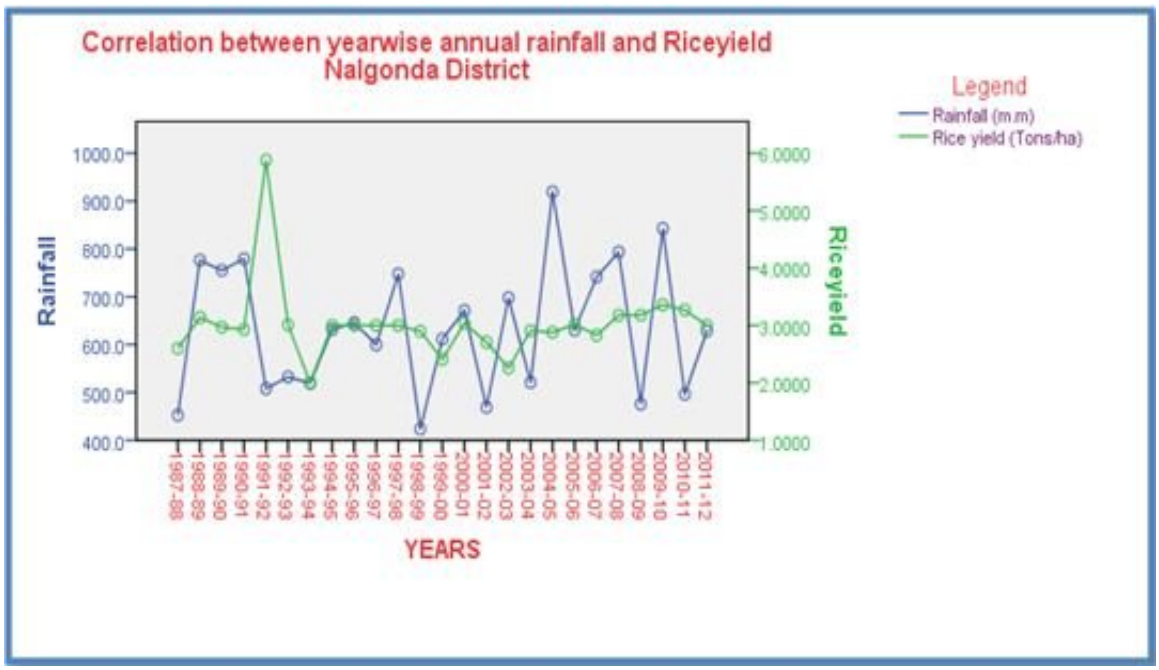
Table-4.9

MANDALS CHOSEN FOR DETAILED ANALYSIS IN NALGONDA DISTRICT						
S.NO	**Mandals**	**Annual rainfall**	**Normal rainfall**	**CoV**	**Percentage Deviation**	**R^2 Values**
Northern Telangana Zone						
1	MOTHEY	439.1	806.1	61.9	-45.5	0.04
2	NADIGUDEM	691.0	870.7	36.3	-20.6	0.02
3	MUNAGALA	746.1	827.0	26.5	-9.8	0.06
4	KODAD	825.8	889.2	29.6	-7.1	0.09

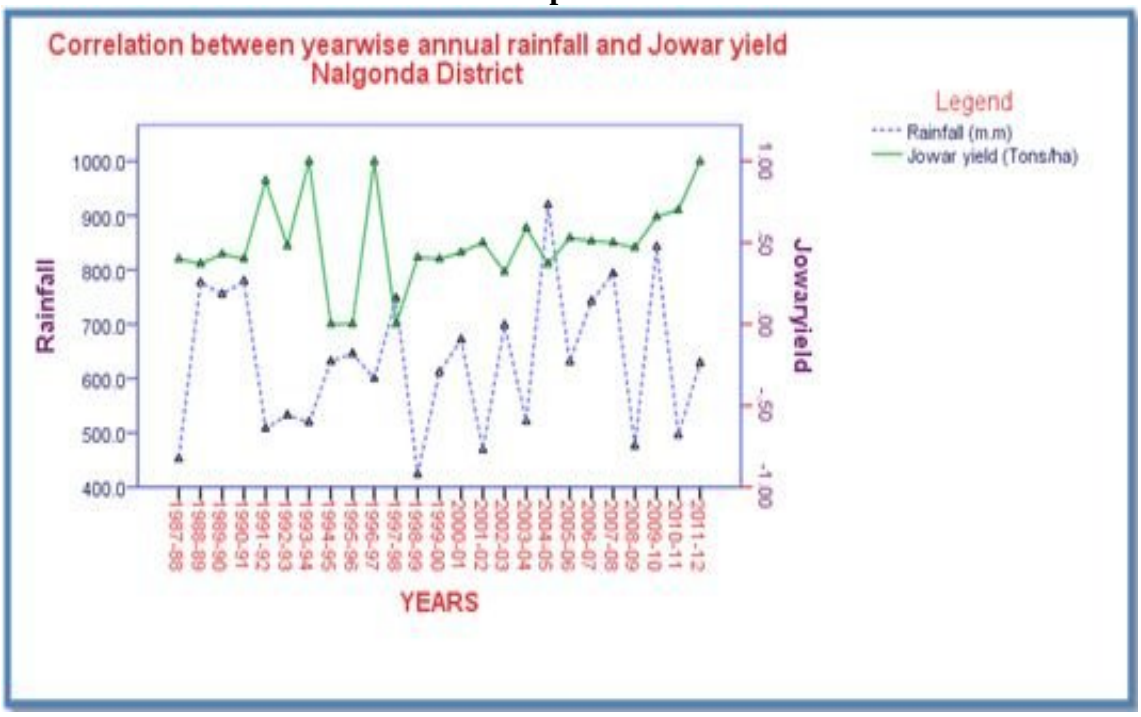
The table-4.9 gives the particulars of the percentage deviation, R^2 values and the coefficient values for the four mandals selected.Similar studies have been conducted by researchers at the mandal levels in various part of the country. In recent years major shift in the rainfall pattern spatially and temporally was observed. In the present study four major crops grown in the district i.e. Rice, Groundnut, Jowar and Chillies were selected to analyse the correlation between agricultural productivity and rainfall patterns.Data was collected based on variations in yields for the period of 1987 – 88 to 2011 – 12.

Graph (11a to 11d) shows the correlation between the annual rainfall and the crop yield data.From the Graph-11a and Graph-11c, it becomes clear that for Rice and Groundnut there is no direct correlation between the quantum of rainfall and the crop yield.So as far as Rice is concerned other factors like acreage of crop sown, fertilizers, pesticides and other sources of water affect productivity and not rainfall alone.

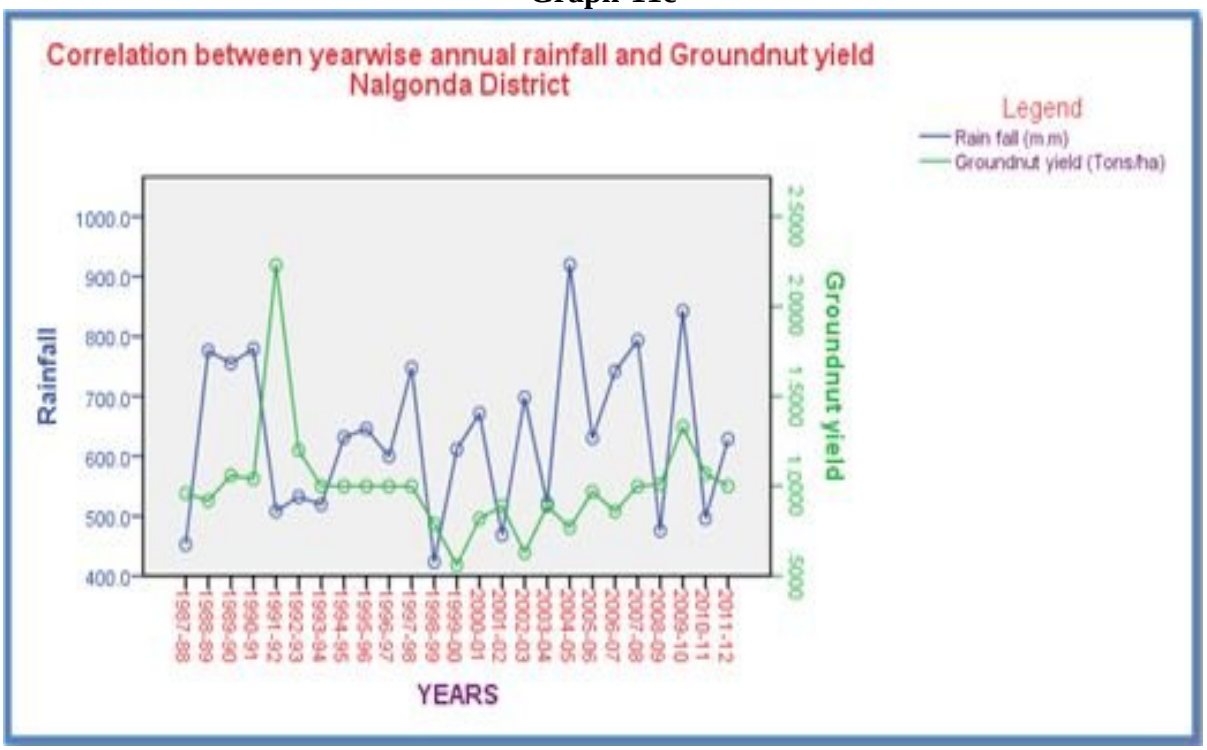
Graph-11a


Correlation between yearwise annual rainfall and Riceyield
Nalgonda District
Legend
Rainfall (m.m)
Rice yield (Tons/ha)
Rainfall
Riceyield
YEARS

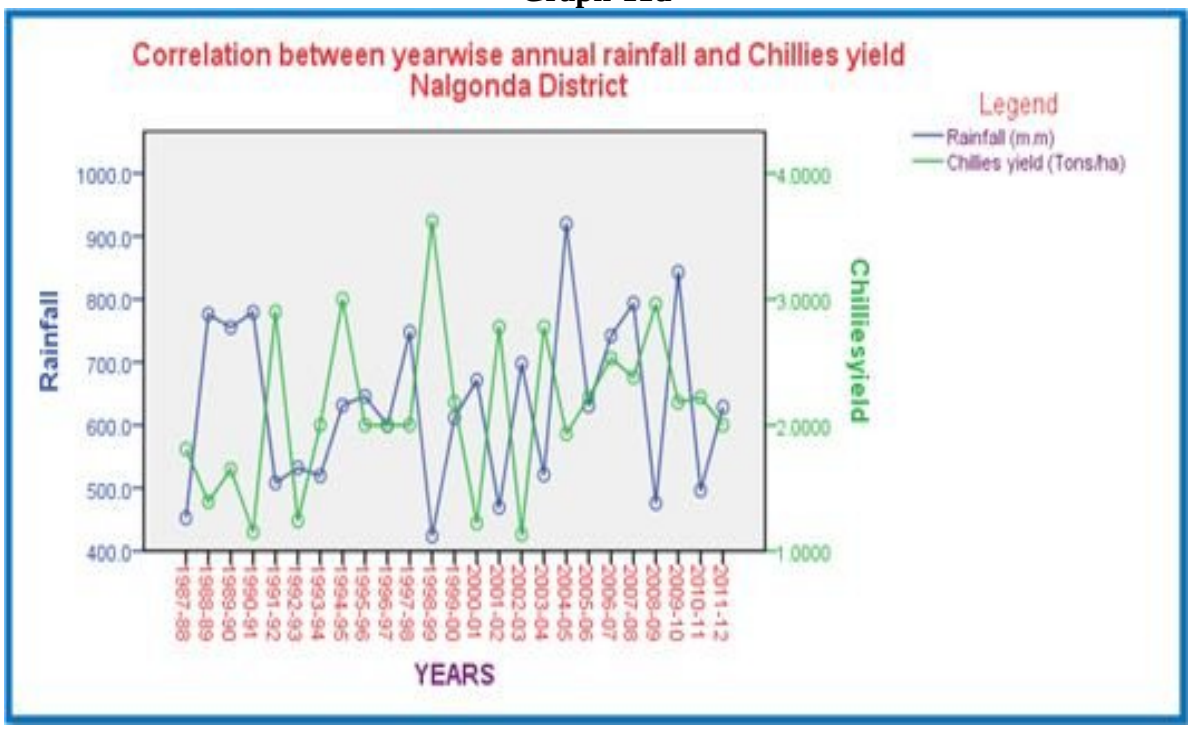
Graph-11b


Correlation between yearwise annual rainfall and Jowar yield
Nalgonda District
Legend
Rainfall (m.m)
Jowar yield (Tons/ha)
Rainfall
Jowaryield
YEARS

Graph-11c



Graph-11d



The crops like Chillies and Jowar showed a distinct positive correlation between yield and rainfall.The graph 11b shows that a direct relationship exists between agricultural productivity and annual rainfall.The graph 11a shows that like Rice crop, there is no correlation between the rainfall pattern and the crop yield, as mentioned earlier crops like Rice and chilly have a mixed response to rainfall and so other parameters must be considered to establish correlation like fertilizers, pesticides etc.

In this study a cluster analysis was carried out for the four crops like Rice, Chillies, Jowar and Groundnut depending on the results of the crop yields and rainfall patterns. The analysis confirms the fact that there is a one to one correlation between rainfall and crop yield as far as Groundnut crop is concerned.

When the climatic parameters (rainfall and temperature) were analysed exhaustively it was ascertained that complex changes affected crop productivity in the district. And therefore, a crop productivity analysis was carried out for a long duration of 25 years at the district level.Rice and Groundnut which is the major crop of the region were taken into consideration the results indicate that rice and groundnut's annual productivity shows decrease in the productivity for the period 1993 – 94, 1999-2000 and 2002 – 03.The decrease in productivity was due to decreased southwest monsoon rainfall in the same period as reported by the rainfall analysis.However, other years have shown an increasing trend in the groundnut productivity.

Therefore, it was clear that only rainfall cannot be an indicator for the changes in crop productivity.In order to further assess the impact of other parameters like fertilizers, human labour hour on agricultural production in addition to climatic variables of the Nalgonda district; the multiple regression equation has been used.The multiple regression equation takes the form $y=b_1X_1 + b_2X_2 + \ldots\ldots + b_nX_n + c$. The regression values obtained from the 25 years data for the four crops are presented in Table-4.10.

Table-4.10 Regression Values for the four crops for the period 1988 – 2012 in Nalgonda District.

Coefficient values for Rice							
Cases	**Constant**	**Act-avg**	**Max-tem**	**Min-tem**	**Fertilizers**	**Human labour**	**R^2**
Case 1	91.055	0.204	49.737	44.648	0.972	-0.168	0.131
Case 2	239.563	###	49.773	44.750	0.974	-0.167	0.131
Case 3	-307.085	0.183	53.249	47.740	1.266	###	0.130
Case 4	517.828	0.254	50.114	47.277	###	-0.510	0.125
Case 5	-1599.470	0.209	78.646	77.856	###	###	0.102
Coefficient values for Groundnut							
Case 1	4669.43	-0.42	8.75	-19.79	-7.58	-2.27	0.266
Case 2	4357.10		8.74	-19.85	-7.57	-2.27	0.266
Case 3	2514.60	-0.49	14.14	-47.59	-4.14	###	0.142

Case 4	4010.55	-0.40	-31.29	-62.19	###	-0.41	0.043
Case 5	3474.35	-0.42	-24.48	-64.66	###	###	0.036
Coefficient values for Chillies							
Case 1	5308.98	-2.87	46.39	-119.87	1.44	-0.59	0.434
Case 2	3160.68	###	46.34	-119.87	1.42	-0.60	0.434
Case 3	5012.48	-2.98	45.50	-140.31	2.67	###	0.433
Case 4	5352.60	-2.78	53.44	-99.84	###	-1.08	0.433
Case 5	3716.38	-3.02	86.22	-119.92	###	###	0.412
Coefficient values for Jowar							
Case 1	2203.34	-0.21	-2.56	18.44	-10.44	-6.68	0.260
Case 2	2045.20	###	-2.56	18.41	-10.44	-6.68	0.260
Case 3	-131.34	-0.25	3.63	21.72	2.93	###	0.184
Case 4	511.36	-0.24	-0.31	20.42	###	-1.66	0.215
Case 5	-590.90	-0.28	21.46	25.33	###	###	0.093

The results indicate that the variable used in the study showed about 13.1% of variation in the productivity of rice, while the overall crop has a positive coefficient, implying that the variables of average rainfall, temperature (maximum and minimum) and fertilizers has a positive impact on productivity.However, in comparison between the average and% deviation of rainfall more accurate result was obtained with the latter data set.The weather parameters actual rainfall and temperatures show a variation of only 10% on the rice productivity.

The results for Jowar indicate a 26% of variation in Jowar yield.However, unlike rice, actual rainfall, mean maximum temperature, fertilizer use and human labour hour had a negative co efficient while the mean minimum temperature is showing a positive impact on the Jowar yields, the negative impact of fertilizers may be due to the over application by farmers which could be theoretically incorrect. Similarly, the actual average rainfall and temperatures were showing a variation of 9% only on the Jowar yields whereas the rainfall and maximum temperatures are showing negative co efficient implying that these values would affect the Jowar productivity negatively.

As far as the Chillie crops are concerned a variation of 43.4% was shown on the yields due to variation in the weather parameters and human labour hour.Except for the maximum temperature all other variables were showing negative impact on Chillies crop productivity.As far as the Groundnut crop was concerned there was a variation of 26.6% due to the four variables - rainfall, temperature, fertilizer and human labour. They show negative impact. However, fertilizers and high temperature did not bring about much alteration in crop yield.It is unfortunate that farmers are overusing fertilizers for this crop, as fertilizers have a negative impact on Groundnut crops.Temperature variation does not have a great effect on either Rice or Groundnut yield.

Sushila Kaul had undertaken a same sort of study on the overall effect of rainfall maximum and minimum temperatures, fertilizers input and human labour hour on the output of Rice and Jowar crops. She used the multiple regression equations for the year 2000-01 to calculate the yield and its correlation with weather parameters. The study revealed that excessive rains and extreme variation in temperature affected crop productivity negatively and this in turn affected the incomes of farmers in a drastic way. A similar sort of study was carried out by H. Mongi et al. on the vulnerability of rain fed crops to weather change in the semi-arid parts of the Tabora region of Tanzania in the year 2009. The meteorological data results showed that during the season from October to April the annual rainfall data had been declining for 35 seasons from 1973-74 to 2007-08. The total rainfall appeared to decrease to a non-significant rate.

Table-4.11 Regression Values for Rice in Karif and Rabi Seasons in Mahabubnagar District

Table-4.11a Regression values for Rice in Kharif and Rabi Seasons of Kodad Mandal							
Coefficient values for Rice- Kharif Season							
Kodad Mandal	**Constant**	**Act-avg**	**Max-tem**	**Min-tem**	**Fertilizers**	**Human labour**	**R^2**
Case 1	787.359	-3.097	-162.701	83.260	4.099	3.485	0.144
Case 2	466.649	###	-162.701	83.260	4.099	3.485	0.144
Case 3	7246.550	0.436	-162.802	30.695	0.757	###	0.040
Case 4	5195.301	-0.635	-166.241	131.212	###	0.594	0.039
Case 5	6703.767	0.168	-164.774	82.947	###	###	0.029
Coefficient values for Rice- Rabi Season							
Kodad Mandal	**Constant**	**Act-avg**	**Max-tem**	**Min-tem**	**Fertilizers**	**Human labour**	**R^2**
Case 1	2996.542	1.619	-284.367	179.112	4.622	3.322	0.134
Case 2	3018.485	###	-284.367	179.112	4.622	3.322	0.134
Case 3	5713.505	-0.770	-67.919	-23.926	0.676	###	0.017
Case 4	5769.631	-0.759	-37.887	-68.309	###	0.299	0.010
Case 5	5910.619	-0.904	-35.453	-65.011	###	###	0.005

It was a marathon task to conduct calculations at the district level and it would give only a representative picture, so an analysis was undertaken at the mandal level. The district has 59 mandals and so the study was restricted to four mandals and was based on the coefficient of variation which was carried out using 25 years of seasonal data. For the analysis, the two seasons Rabi and Kharif were considered. The mandals chosen for the analysis are Kodad, Mothey, Munagala and Nadigudem.The crop yields data was calculated based on the values of the crop cutting and the averages of the dry yields of the villages that were surveyed and are multiplied with the total area of the surveyed villages and finally their ratio is taken to achieve the yields. Table (4.11a) to (4.11d) presents a season wise analysis of rice in Kharif and Rabi seasons

Using the variables of actual rainfall, temperatures, fertilizers and human labour hour a variation of 14.4% is observed in rice productivity for Kharif crop and 13.4% for the Rabi crop in Kodad mandal. Minimum temperature, fertilizers and human labour show a positive impact on the yield. However maximum temperature and rainfall show a negative impact for the Kharif crop. As far as the Kharif crop is concerned the% deviation shows more negative impact while it was positive for the Rabi crop. The variation shown on the rice yields is 2.9% for the Kharif crop while it was 5.0% for the Rabi crop, when only weather parameters were taken and it was negative for the two seasons as far as the maximum temperature was concerned.

A same sort of analysis was undertaken for Munagala, Mothey and Nadigudam mandals of Nalgonda district and the results are as shown in tables 4.11(b), 4.11(c) and 4.11(d) respectively.

Table 4.11b Regression values for Rice in Kharif and Rabi Seasons of Munagala Mandal

Coefficient values for Rice- Kharif Season							
Munagala Mandal	**Constant**	**Act-avg**	**Max-tem**	**Min-tem**	**Fertilizers**	**Human labour**	**R^2**
Case 1	1532.912	2.343	-35.675	-236.956	5.911	4.062	0.184
Case 2	1758.200	###	-35.675	-236.956	5.911	4.062	0.184
Case 3	9639.678	3.171	-87.517	-200.747	1.112	###	0.043
Case 4	5947.125	4.894	-14.344	-154.856	###	0.770	0.044
Case 5	8454.723	4.204	-52.691	-171.740	###	###	0.029
Coefficient values for Rice- Rabi Season							
Munagala Mandal	**Constant**	**Act-avg**	**Max-tem**	**Min-tem**	**Fertilizers**	**Human labour**	**R^2**
Case 1	172.076	0.387	-265.785	203.863	5.929	4.025	0.164
Case 2	176.142	###	-265.785	203.863	5.929	4.025	0.164
Case 3	5653.631	-1.068	-82.908	-4.613	0.911	###	0.018
Case 4	5911.795	-1.699	-43.805	-77.358	###	0.592	0.017
Case 5	6241.588	-1.535	-46.449	-61.736	###	###	0.006

As far as the Munagala mandal is concerned a variation of 18.4% was found in rice productivity for Kharif crop while it was 16.4% for the Rabi crop. In this mandal, as far as the Kharif crop is concerned the rainfall,fertilizers and human labour show a positive impact while the maximum and minimum temperature show a negative impact on the yield for Kharif crop. For the rice yields the variation shown is 2.9% for the Kharif season and 6.0% for Rabi when only weather parameters ware considered. Maximum temperature has a negative impact on crop productivity both for Kharif and Rabi seasons.

Table 4.11c Regression values for Rice in Kharif and Rabi Seasons of Mothey Mandal

Coefficient values for Rice- Kharif Season							
Mothey Mandal	**Constant**	**Act-avg**	**Max-tem**	**Min-tem**	**Fertilizers**	**Human labour**	**R^2**
Case 1	311.926	5.849	-66.119	-43.542	5.160	2.328	0.219
Case 2	855.461	###	-66.119	-43.542	5.160	2.328	0.219
Case 3	5732.948	7.404	-86.243	-84.692	2.657	###	0.164
Case 4	4275.931	5.807	-102.534	85.273	###	0.166	0.115
Case 5	4728.877	6.011	-102.853	71.854	###	###	0.114
Coefficient values for Rice- Rabi Season							
Mothey Mandal	**Constant**	**Act-avg**	**Max-tem**	**Min-tem**	**Fertilizers**	**Human labour**	**R^2**
Case 1	384.157	1.183	116.213	-77.485	2.100	-1.514	0.719
Case 2	400.689	###	116.213	-77.485	2.100	-1.514	0.719
Case 3	-1165.658	0.223	41.393	-10.298	3.967	###	0.666
Case 4	2008.173	1.620	199.279	-166.669	###	-2.740	0.671
Case 5	1321.677	-2.062	192.853	-244.476	###	###	0.048

In terms of rice productivity, a variation of 21.9% is observed for the Kharif season and 71.9% for the Rabi crop. In the Mothey mandal except for rainfall, fertilizers and human labour the temperatures have shown a negative impact. The negative impact of maximum temperature is less when compared to the other two mandals. And compared to the other two mandals the% deviation shows a more positive impact than the actual rainfall. The rice yields show a variation of 11.4% and maximum temperatures have a negative impact on the yields in kharif season.

Table 4.11d Regression values for Rice in Kharif and Rabi Seasons of Nadigudem Mandal

Coefficient values for Rice- Kharif Season							
Nadigude Mandal	**Constant**	**Act-avg**	**Max-tem**	**Min-tem**	**Fertilizers**	**Human labour**	**R^2**
Case 1	255.980	1.283	-111.383	19.744	4.659	2.654	0.141
Case 2	386.266	###	-111.383	19.744	4.659	2.654	0.141
Case 3	6125.092	2.306	-135.047	10.284	1.119	###	0.058
Case 4	2489.534	3.177	-113.212	139.852	###	0.851	0.067
Case 5	5254.080	2.902	-127.971	73.123	###	###	0.049
Coefficient values for Rice- Rabi Season							
Nadigude Mandal	**Constant**	**Act-avg**	**Max-tem**	**Min-tem**	**Fertilizers**	**Human labour**	**R^2**
Case 1	1363.615	1.253	-267.406	164.466	5.223	4.231	0.172
Case 2	1383.464	###	-267.427	164.278	5.222	4.230	0.172
Case 3	6228.983	-2.474	-81.984	-27.367	0.704	###	0.020
Case 4	6772.698	-4.111	-56.053	-94.186	###	0.520	0.018
Case 5	6867.145	-3.645	-54.751	-77.900	###	###	0.009

An attempt was also made in the study to correlate the agricultural GDP and the Prices.An analysis was done using the ordinary least square model (OLS) to ascertain the impact of weather variable on the agricultural GDP.The R2 values were estimated using the OLS model and its importance was analysed for two data sets- (1) Prices, Rainfall and Agricultural productivity (2) GDP, Prices, Rainfall and Agricultural productivity. The table-4.12 below presents multiple R and R2 values.The finding was that the production and prices were affected by difference in rainfall. Without GDP the R2 values varied from 0.57 to 0.14 and with GDP the R2 values varied from 0.64 to 0.75.All the crops with GDP have shown a direct impact of rainfall on agricultural productivity.

Table-4.12 Findings of Fitted Models through Ordinary Least Square Method – Nalgonda District

Commodities	Prices, Rainfall, Production			GDP, Prices, Rainfall Production	
	Observations	Multiple R	R Square	Multiple R	R Square
Rice	25	0.76	0.57	0.85	0.73
Groundnut	25	0.57	0.32	0.87	0.75
Chillies	25	0.37	0.14	0.80	0.64
Jowar	25	0.66	0.43	0.84	0.71

WARANGAL DISTRICT

The coefficients of variance (COV) for all the 59 mandals of Warangal district were calculated.From this district four mandals were chosen for a detailed study of the correlation between rainfall and crop yield.

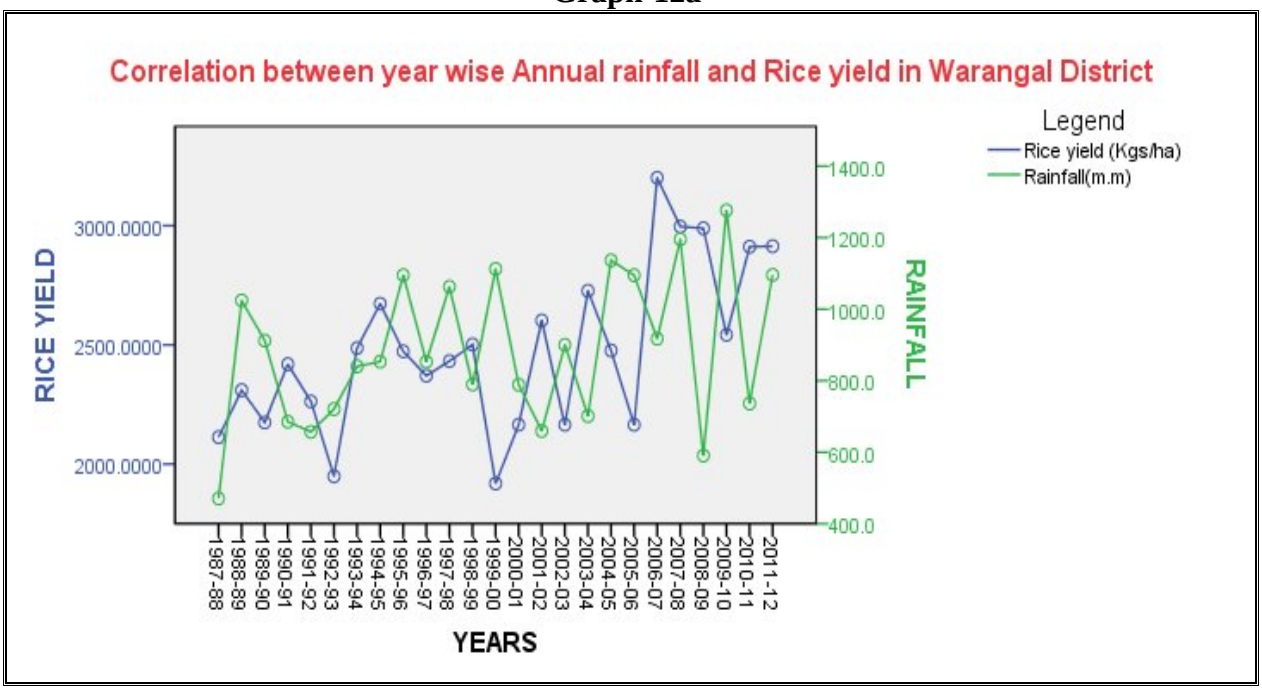
Out of these four mandals, two mandals – Maripaeda and Raghunathapalle were selected because of their high COV value (79.16 and 81.46 respectively) and two mandals Jangaon and Mulugu were selected because of their low COV value (24.07 and 23.77 respectively).These facts are highlighted in the table-4.13 given below.

Table-4.13 MANDALS CHOSEN FOR DETAILED ANALYSIS IN WARANGAL DISTRICT

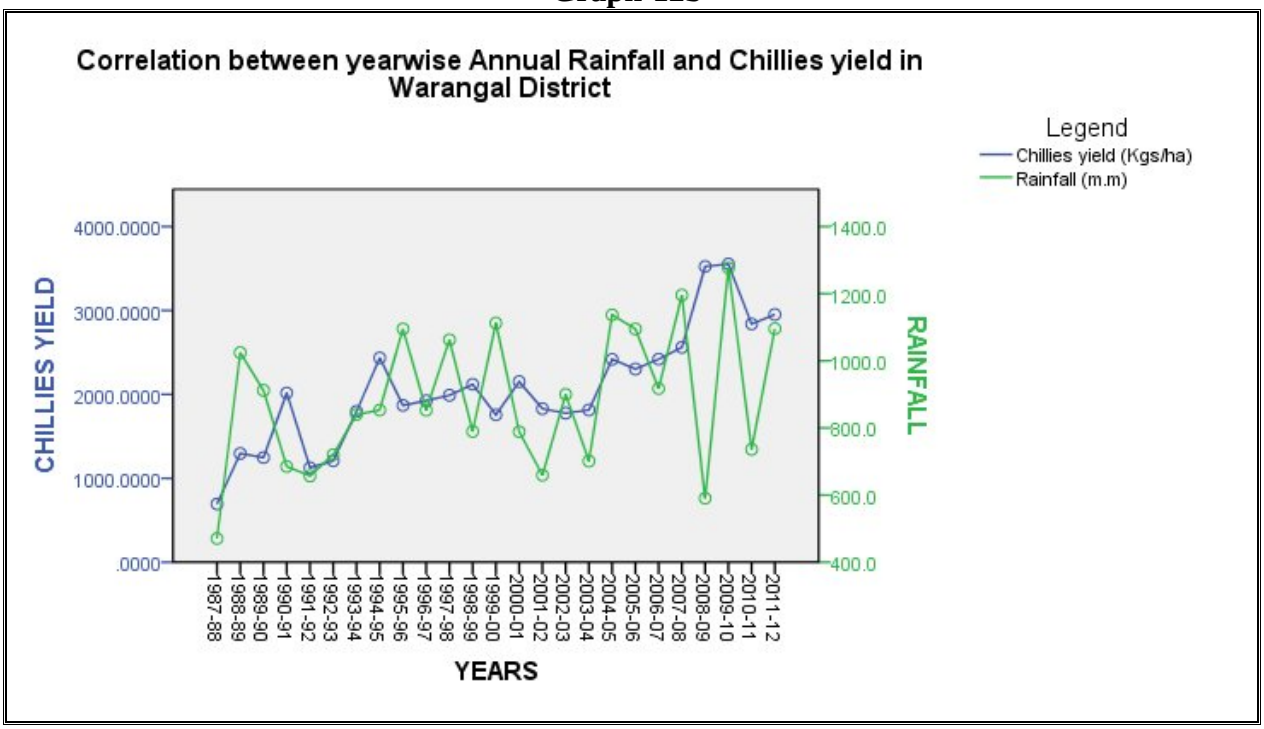
S.No.	Mandals	Annual Rainfall	Normal Rainfall	CoV	Percentage Deviation	R^2 Values
1	MARIPEDA	550.4	824.6	79.16	-33.3	0.42
2	RAGHUNATHA PALLE	543.5	828.8	81.46	-34.4	0.54
3	JANGAON	850.0	815.6	24.07	4.2	0.00
4	MUGLUG	1206.1	1217.9	23.77	-1.0	0.01

In this study the major crops selected for this district were Rice, Jowar, Maize and Chillies.These crops were chosen to analyse the correlation between rainfall and crop yield.From Graph-12(a) to 12(d) it becomes obvious that in spite of a moderately good rainfall the crop yield as far as Rice and Chillies are concerned was low.A similar study has been undertaken for Jowar and Maize.

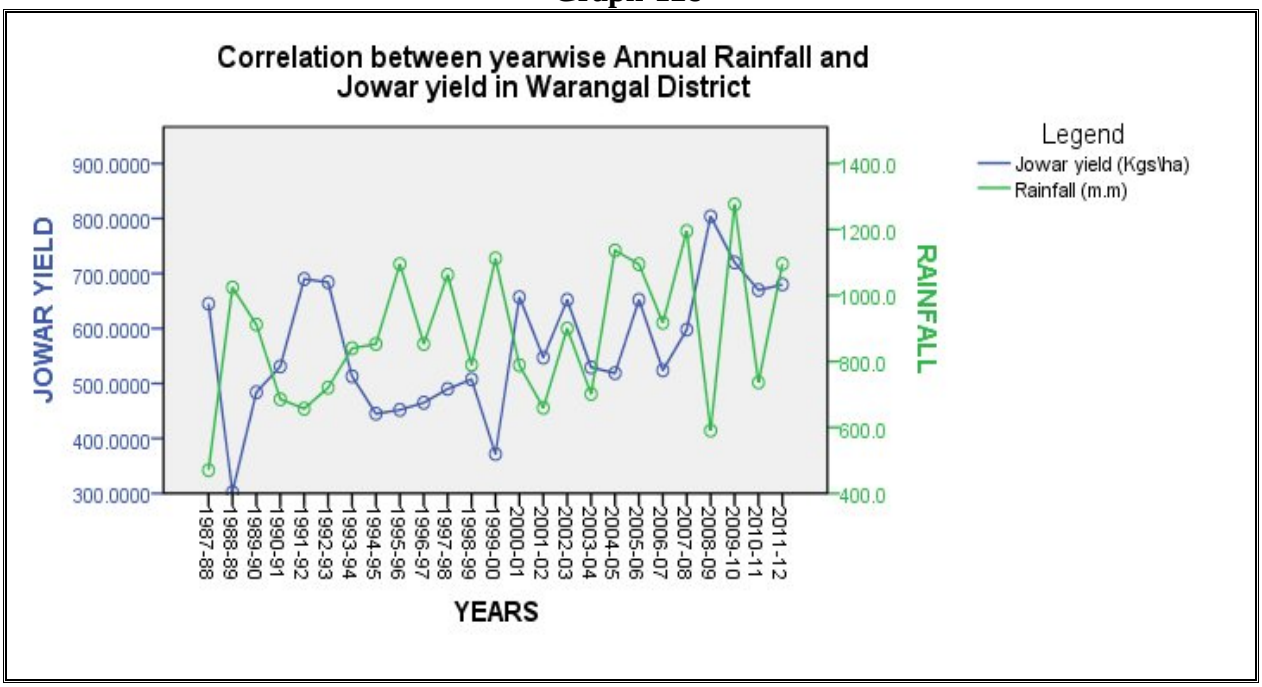
Graph-12a



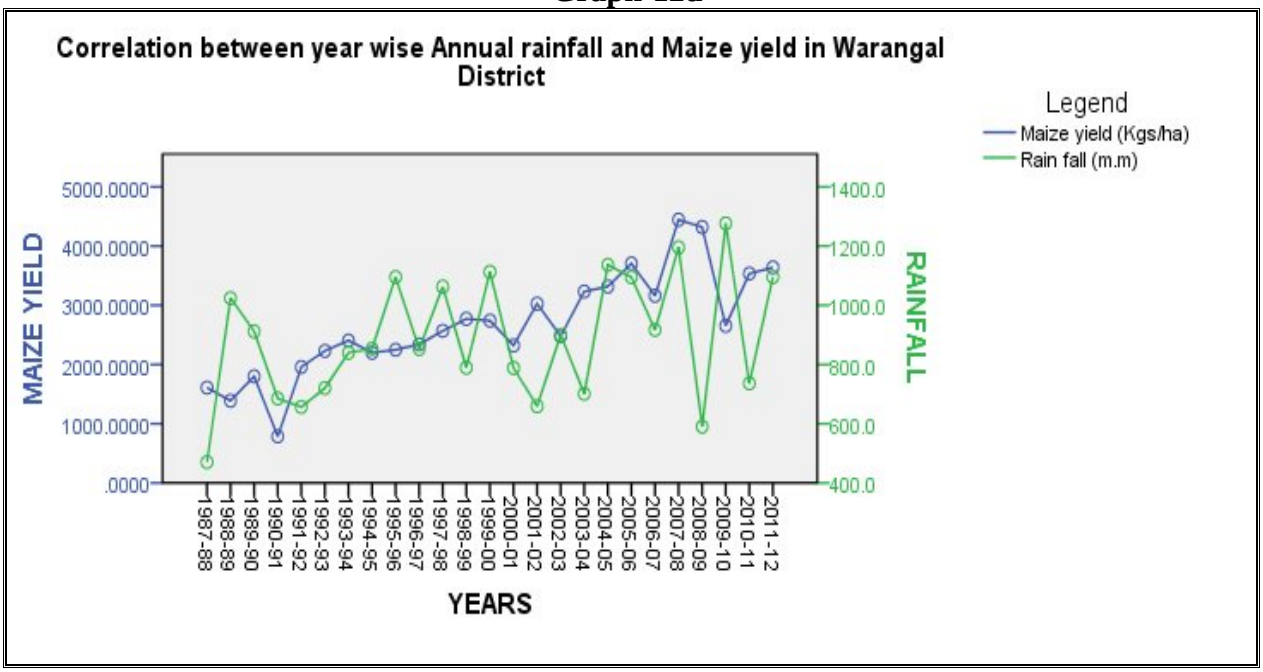
Graph-12b



Graph-12c



Graph-12d



From the above graphs it becomes clear that there is a distinct positive correlation between yield and rainfall.For Jowar and Maize, a decrease in rainfall brings about a decrease in crop yield.

In the case of Rice, it is not the amount of rainfall alone that determines increased yield, but there are other factors like fertilizers, pesticides, other sources of water etc.

Further a regression coefficient is computed for the four major crops of the district.The major crops taken are Rice, Jowar, Maize and Chillies.At the district level all the crops have shown above 60% R^2 values, from which we can infer that all the climatic parameters have a positive impact on the crop yield.The following table-4.14 highlights in detail the R^2 values under each crop of the district.

Table-4.14 Regression Values for the four crops for the period 1988 – 2012 in Warangal District.

District Level Coefficient Values							
Cases	**Constant**	**Act-avg**	**Max-tem**	**Min-tem**	**Fertilizers**	**Humanlabour**	**R^2**
Coefficient values for Rice							
Case 1	1968.291	-.331	43.581	126.434	-1.453	-2.604	.630
Case 2	3673.688	-.359	###	128.873	-1.379	-2.861	.626
Case 3	2889.670	-.362	###	101.992	###	-2.145	.501
Case 4	2676.468	###	###	86.356	###	-1.926	.458
Coefficient values for jowar							
Case 1	-294.297	-.216	70.644	-6.409	-7.271	-4.104	.663
Case 2	-513.671	-.219	72.912	###	-7.344	-4.068	.660
Case 3	-1652.535	-.227	73.376	###	###	-.472	.534
Case 4	-2268.108	-.206	88.625	###	###	###	.528
Coefficient values for Maize							
Case 1	15001.551	-.198	-99.946	-124.680	.681	-6.197	.755
Case 2	14648.014	###	-90.115	-126.757	.482	-6.180	.753
Case 3	15614.905	###	-95.867	-130.508	###	-6.549	.752
Case 4	11256.261	###	###	-107.463	###	-5.986	.748
Coefficient values for Chillies							
Case 1	-5679.421	.426	257.557	-82.616	2.635	-.962	.756
Case 2	-8944.813	.443	309.264	###	1.935	-.890	.745
Case 3	-6728.557	###	248.551	###	2.653	-1.059	.732
Case 4	-8283.650	###	355.156	###	###	-1.330	.704

The two seasons Kharif and Rabi were considered to calculate the coefficient values for Rice of the four mandals of Warangal district, using the variables of actual rainfall, temperatures, fertilizers and human labour. The R^2 value of crop yield in Jangaon mandal was 42.3% in Kharif season when all the above-mentioned variables were

applied. Subsequently when the variable of minimum temperature was excluded it had no impact on crop yield and the R_2 value was same (42.3%).

However, when the variables of fertilizers and minimum temperature were not considered the R^2 value started decreasing which indicated an impact on the yield.In the Rabi season with all the variables the R^2 value was 55.7%.When the variable of rainfall was not considered also, R^2 value remained the same 55.6%.However, when maximum temperature and rainfall were removed the R_2 value started decreasing.The table indicates that in the Rabi season the minimum temperature alone shows a positive impact on crop yield.

Further maximum temperature, fertilizers and human labour have shown a negative impact on the yield in the Rabi season.The variation shown on the Rice yield is 40.5% in the Kharif season while it is 53% in the Rabi season, and it indicates that weather parameters such as maximum temperature and rainfall have a positive impact on the yield in the Khariff season and as far as the Rabi season is concerned rainfall and minimum temperature have a positive impact whereas maximum temperature has a negative impact.In both Kharif and Rabi seasons, the parameters of fertilizers and human labour have displayed a negative impact.

A similar analysis was undertaken for Maripeda, Mulugu and Raghunathapally mandals of Warangal district and the results are as shown in the table-4.15

Table-4.15 Regression Values for Rice in Kharif and Rabi Seasons in Warangal District

Coefficient values for Kharif and Rabi							
Cases	**Constant**	**Act-avg**	**Max-tem**	**Min-tem**	**Fertilizers**	**Humanlabour**	**R^2**
Coefficient values for Kharif Rice Jangaon							
Case 1	1119.178	1.386	85.761	3.948	-.382	-1.333	.423
Case 2	1160.688	1.432	85.638	###	-.335	-1.309	.423
Case 3	714.755	1.348	88.698	###	###	-1.117	.421
Case 4	4408.253	.958	###	###	###	-1.841	.405
Coefficient values for Rabi Rice Jangaon							
Case 1	3545.749	.684	-30.688	136.676	-.905	-2.670	.557
Case 2	3892.715	###	-38.376	134.893	-.860	-2.691	.556
Case 3	2595.819	###	###	127.622	-1.024	-2.600	.547
Case 4	1798.942	###	###	117.266	###	-2.060	.531
Coefficient values for Kharif Rice Maripeda							
Case 1	2838.307	-1.079	32.888	29.938	.114	-1.858	.429
Case 2	2892.254	-1.048	33.174	31.515	###	-1.905	.429
Case 3	4305.587	-1.152	###	30.740	###	-2.196	.426
Case 4	4913.931	-.893	###	###	###	-2.138	.417
Coefficient values for Rabi Rice Maripeda							
Case 1	4445.093	-5.233	-52.576	132.233	-.412	-2.783	.574

Case 2	4374.669	-5.885	-58.066	129.163	###	-2.623	.572
Case 3	2160.463	-5.067	###	115.873	###	-2.314	.552
Case 4	1798.942	###	###	117.266	###	-2.060	.531
Coefficient values for Kharif Rice Mulug							
Case 1	2459.120	-1.468	46.949	40.472	-.468	-1.794	.437
Case 2	2062.584	-1.449	50.085	31.623	###	-1.531	.434
Case 3	4195.243	-1.545	###	28.673	###	-1.932	.429
Case 4	4802.641	-1.259	###	###	###	-1.934	.420
Coefficient values for Rabi Rice Mulug							
Case 1	5156.877	-3.220	-62.907	126.689	-.879	-2.771	.563
Case 2	3892.715	###	-38.376	134.893	-.860	-2.691	.556
Case 3	2595.819	###	###	127.622	-1.024	-2.600	.547
Case 4	1798.942	###	###	117.266	###	-2.060	.531
Coefficient values for Kharif Rice Raghunathpalli							
Case 1	2158.007	-.345	56.765	25.492	-.330	-1.725	.410
Case 2	1931.023	-.389	57.767	20.103	###	-1.565	.409
Case 3	1509.557	###	67.102	13.986	###	-1.358	.406
Case 4	2080.037	###	61.014	###	###	-1.411	.404
Coefficient values for Rabi Rice Raghunathpalli							
Case 1	4277.243	-2.396	-49.447	135.257	-.640	-2.736	.562
Case 2	4172.527	-3.136	-58.842	130.973	###	-2.476	.557
Case 3	3556.906	###	-47.350	128.287	###	-2.278	.545

Table-4.16 Findings of Fitted Models through Ordinary Least Square Method – Warangal District

Commodities	Prices, Rainfall, Production			GDP, Prices, Rainfall Production	
	Observations	Multiple R	R Square	Multiple R	R Square
Rice	25	0.629	0.395	0.867	0.752
Jowar	25	0.526	0.277	0.904	0.816
Maize	25	0.802	0.643	0.918	0.843
Chillies	25	0.724	0.524	0.873	0.763

From the above table-4.16, it can be inferred that all the crops without GDP have shown the R2 values from 0.64 to 0.27 and with GDP the R2 values varied from 0.75 to 0.84. From this it can be concluded that agricultural productivity and thereby agricultural GDP are vulnerable to vagaries of climate.

COASTAL ANDHRA REGION

The Krishna agroclimatic zone is primarily identified as an agricultural land.The crops grown in the zone are Rice, Groundnut, Maize and Chillies.The two districts namely Krishna and Guntur fall in this zone.The Coastal area of Machilipatnam is most vulnerable to high storm surges and frequent tropical cyclones.

GUNTUR DISTRICT

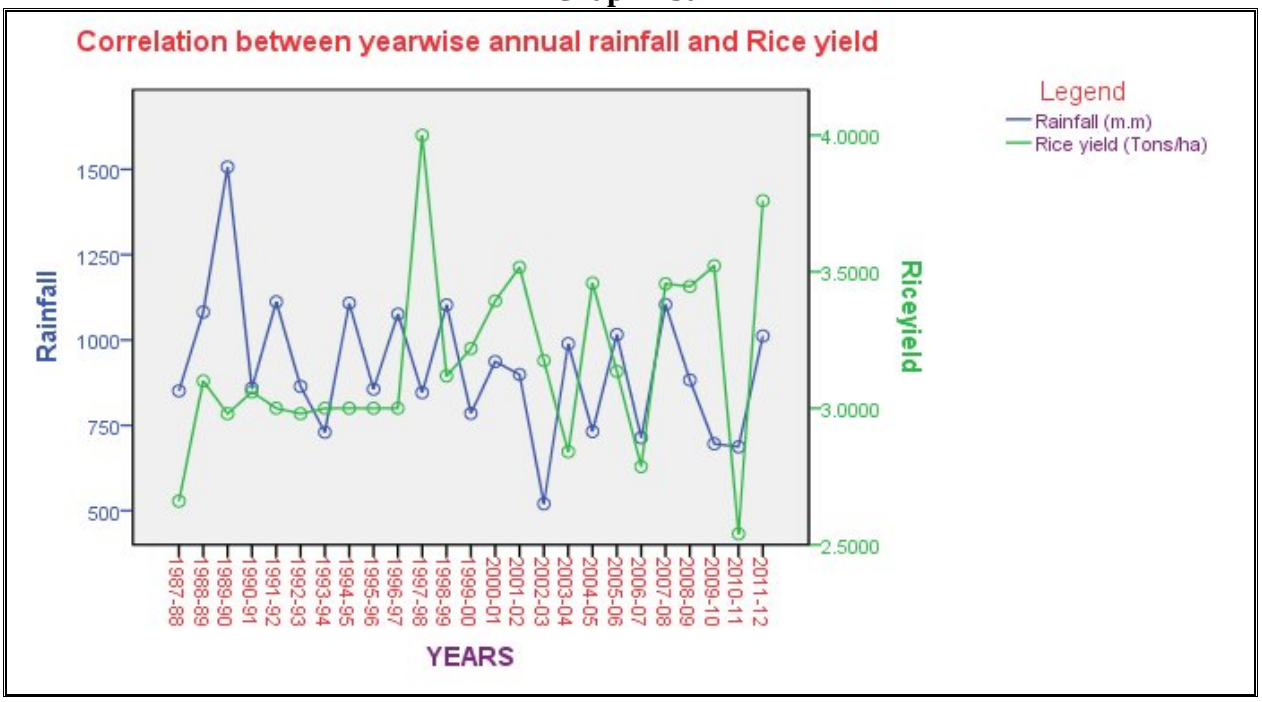
It is one of the Coastal districts of the state of Andhra Pradesh and falls under Krishna Agro climatic zone. The important crops grown in the district are Rice, Maize, Chillies and Groundnut. In this district, three mandals i.e. Bhattiprolu, Kollur and Vemur were selected for high coefficient of variance and three mandals of Cherukupalli, Nagaram and Rapalle were considered for low coefficient of variance. The following table-4.17 shows the distribution of annual rainfall, normal rainfall,percentage deviation and R^2 values for the selected mandals of the district.

Table-4.17 MANDALS CHOSEN FOR DETAILED ANALYSIS IN GUNTUR DISTRICT

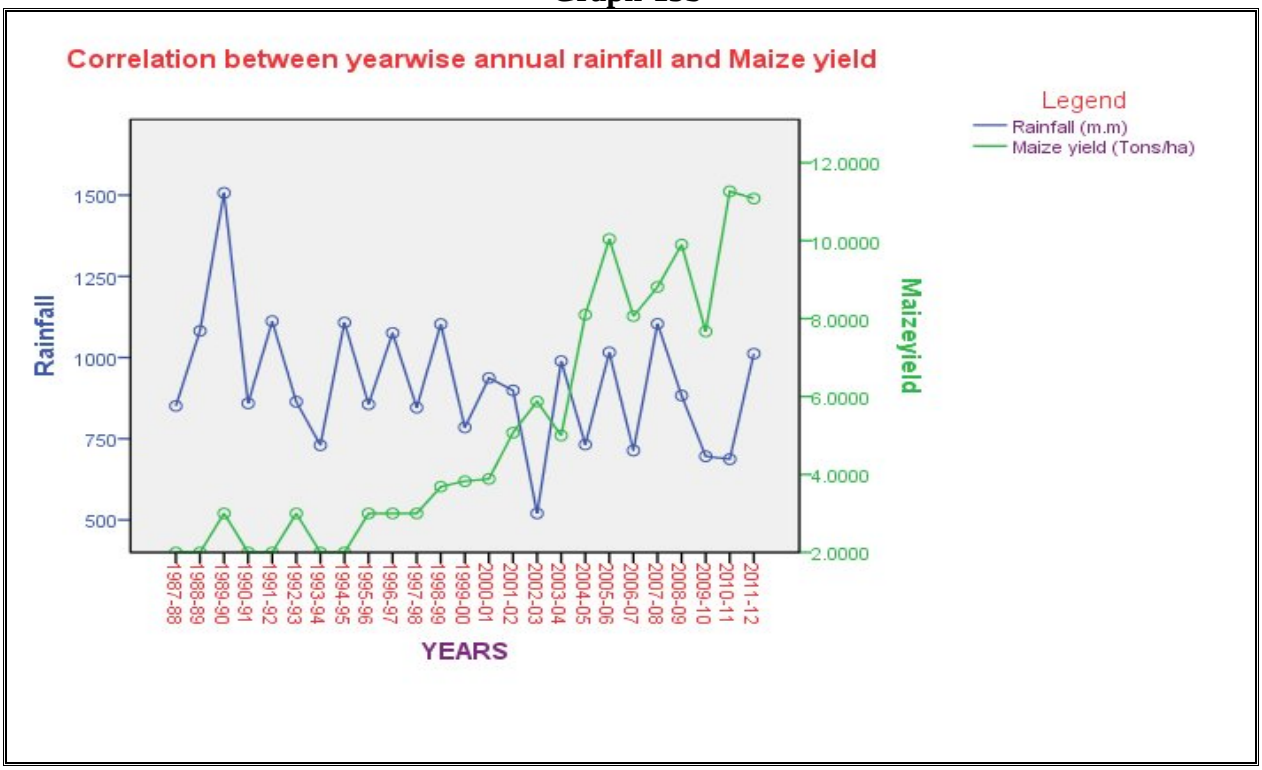
Sl.No.	Mandals	Annual Rainfall	Normal Rainfall	CoV	Percentage Deviation	R^2 Values
	KRISHNA ZONE					
1	BHATTIPROLU	603.83	1060.4	90.12	-43.06	0.57
2	CHERUKUPALLI	883.46	875	26.85	0.97	0.06
3	KOLLUR	790.14	978.9	87.43	-19.28	0.54
4	NAGARAM	1067.13	1010.1	30.07	5.64	0.00
5	REPALLE	1114.09	1046.7	27.57	6.43	0.00
6	VEMUR	674.99	942.8	77.70	-28.41	0.49

The Graphs 13(a) to 13(d) reveals the correlation between annual rainfall and the selected crop yield. The graphs for Rice and Maize have shown a negative correlation, in spite of increase in rainfall there is a decrease in crop yield.The graph showing the correlation between rainfall and the yields for the crops such as Groundnut and Chillies have shown a positive correlation indicating that with an increase in rainfall the yields have also increased.

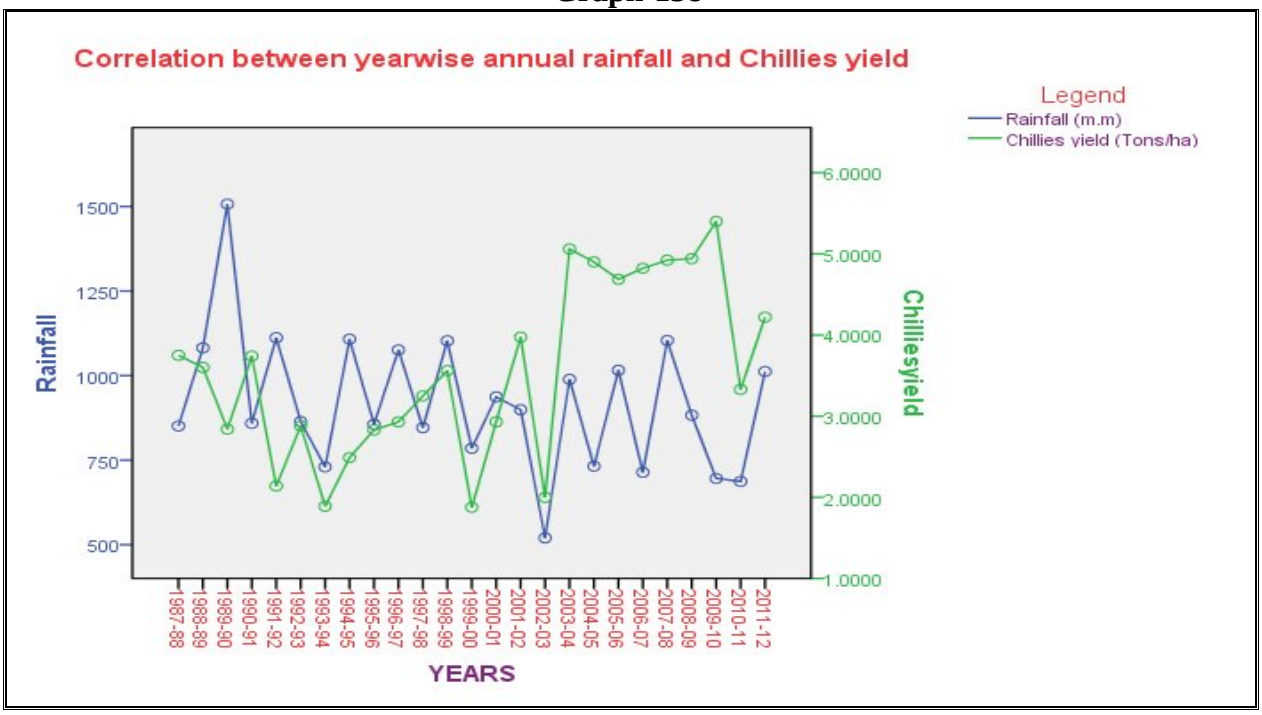
Graph-13a



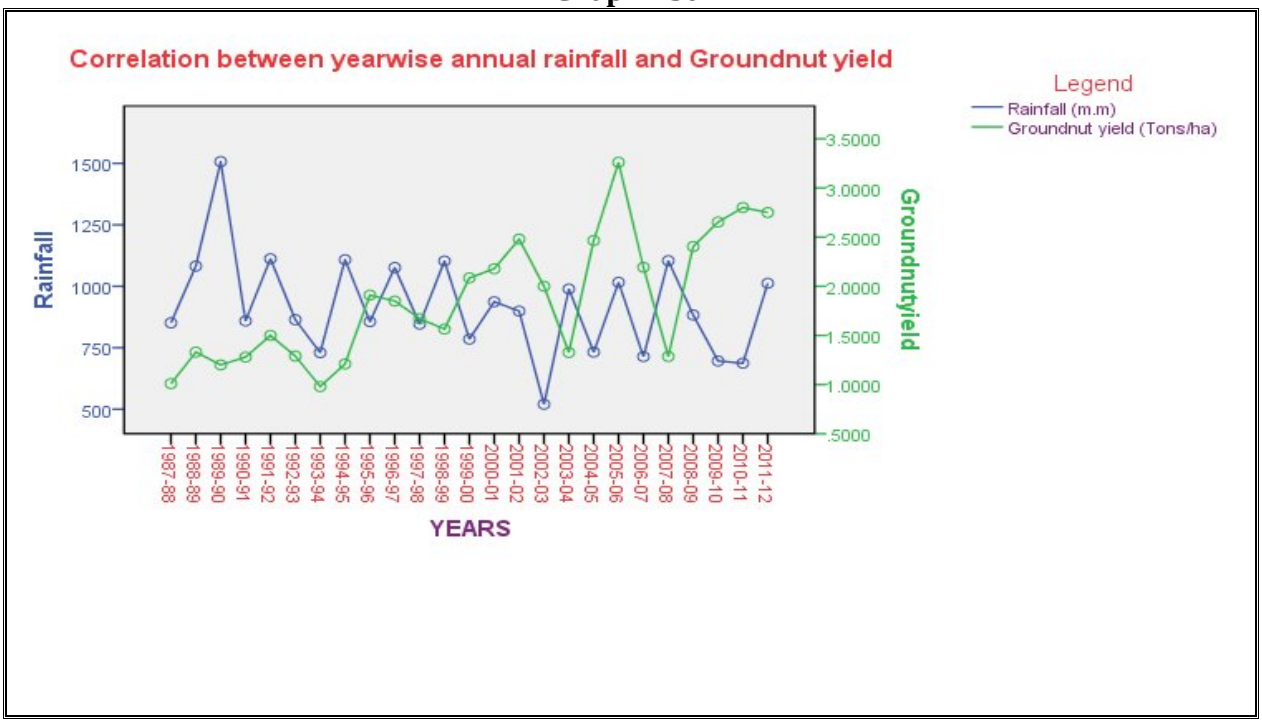
Graph-13b



Graph-13c



Graph-13d



Regression analysis is computed taking the variables of average rainfall, maximum temperature, minimum temperature, fertilizers and human labour deviation to get the R^2 value.The R^2 for Rice, Maize, Chillies and Groundnut showed 53.9%, 62.5%, 27.0% and 55.4% respectively; except for Maize crop (62.5%) other crops have less than 60% R^2 value. For these crops the model is inadequate to explain the variation between crop yield and rainfall for the district.

Table-4.18 Regression Values for the four crops for the period 1988 – 2012 in Guntur District.

Cases	Constant	Act-avg	Max-tem	Min-tem	Fertilizers	Humanlabour	R^2
Coefficient values for Rice							
Case 1	-12897.112	0.752	227.852	325.601	0.202	0.158	0.539
Case 2	-12254.197	###	228.429	324.770	0.201	0.158	0.540
Case 3	-12440.125	0.745	228.156	317.151	0.042	###	0.538
Case 4	-12571.922	0.772	232.631	314.251	###	0.055	0.539
Coefficient values for Maize							
Case 1	48065.705	-2.318	-1415.527	462.570	14.190	-13.339	0.625
Case 2	46073.455	###	-1415.420	462.990	14.189	-13.338	0.625
Case 3	8923.969	-1.589	-1402.829	1129.550	28.132	###	0.539
Case 4	71147.256	-1.070	-1111.682	-295.508	###	-20.578	0.578
Coefficient values for Chillies							
Case 1	17662.432	-1.084	-1093.706	997.963	3.600	-2.054	0.270
Case 2	16729.172	###	-1093.395	997.862	3.599	-2.054	0.270
Case 3	11634.454	-0.972	-1091.751	1100.681	5.747	###	0.253
Case 4	23518.308	-0.767	-1016.620	805.636	###	-3.891	0.245
Coefficient values for Groundnut							
Case 1	2225.961	0.026	74.422	-112.572	13.678	-2.385	0.554
Case 2	2249.711	###	74.309	-112.458	13.678	-2.386	0.554
Case 3	-407.492	0.140	116.584	-204.194	21.607	###	0.537
Case 4	4889.238	0.075	34.388	29.259	###	-5.427	0.516

The mandal wise (selected mandals) regression analysis for Rice crop in Kharif and Rabi is shown in the following table-4.19.

Table-4.19 Regression Values for Rice in Kharif and Rabi Seasons in Guntur District

Cases	Constant	Act-avg	Max-tem	Min-tem	Fertilizers	Humanlabour	R2
Coefficient values for Rice In Bhattiprolu Mandal (Kharif)							
Case 1	50.071	2.947	-123.965	255.195	0.539	0.731	0.408
Case 2	465.388	###	-123.965	255.195	0.539	0.731	0.408
Case 3	3083.740	2.499	-160.289	222.168	0.001	###	0.393
Case 4	387.426	2.844	-120.386	263.434	###	0.459	0.402

Coefficient values for Rice In Bhattiprolu Mandal (Rabi)							
Case 1	-7702.114	5.599	43.261	377.079	1.047	-0.703	0.563
Case 2	-7569.687	###	43.261	377.079	1.047	-0.703	0.563
Case 3	-8954.625	6.775	35.145	391.500	1.755	###	0.534
Case 4	-5657.305	5.861	31.544	350.058	###	-0.992	0.545
Coefficient values for Rice In Kollur Mandal (Kharif)							
Case 1	4139.747	1.489	-178.258	194.028	0.319	-0.012	0.291
Case 2	4327.196	###	-178.258	194.028	0.319	-0.012	0.291
Case 3	4095.165	1.493	-177.774	194.477	0.329	###	0.291
Case 4	4407.618	1.462	-175.881	197.160	###	-0.214	0.289
Coefficient values for Rice In KollurMandal (Rabi)							
Case 1	-8162.013	3.995	30.298	423.223	0.831	-0.723	0.556
Case 2	-8081.320	###	30.298	423.223	0.831	-0.723	0.556
Case 3	-9678.512	4.115	18.687	449.937	1.682	###	0.535
Case 4	-6648.177	4.260	26.394	404.385	###	-1.103	0.545
Coefficient values for Rice In Vemur Mandal (Kharif)							
Case 1	3339.568	2.132	-166.807	213.474	0.169	0.046	0.312
Case 2	3598.575	###	-166.807	213.474	0.169	0.046	0.312
Case 3	3513.126	2.114	-168.650	211.509	0.135	###	0.312
Case 4	3476.424	2.124	-165.092	214.535	###	-0.058	0.312
Coefficient values for Rice In VemurMandal (Rabi)							
Case 1	-7729.593	2.841	15.457	419.922	1.070	-0.685	0.532
Case 2	-7666.732	###	15.457	419.922	1.070	-0.685	0.532
Case 3	-9198.499	3.245	7.343	442.104	1.877	###	0.514
Case 4	-5636.933	2.696	5.262	398.270	###	-1.189	0.514
Coefficient values for Rice In Repalle Mandal (Kharif)							
Case 1	3903.756	1.844	-145.564	236.520	-0.925	-1.063	0.230
Case 2	4161.065	###	-145.564	236.520	-0.925	-1.063	0.230
Case 3	-800.315	1.743	-114.558	324.247	0.089	###	0.181
Case 4	4238.777	1.397	-184.254	237.390	###	-0.735	0.216
Coefficient values for Rice In Repalle Mandal (Rabi)							
Case 1	-7327.349	0.922	-10.138	452.242	0.938	-0.846	0.523
Case 2	-7304.294	###	-10.138	452.242	0.938	-0.846	0.523
Case 3	-8906.914	0.474	-25.491	478.424	1.937	###	0.495
Case 4	-5591.553	1.133	-17.229	434.631	###	-1.295	0.509
Coefficient values for Rice In Cherukupalli Mandal (Kharif)							
Case 1	3599.163	1.915	-157.808	219.107	0.147	-0.637	0.213
Case 2	3816.334	###	-157.808	219.107	0.147	-0.637	0.213
Case 3	1142.929	1.850	-143.981	265.677	0.651	###	0.202
Case 4	3713.147	2.004	-152.094	214.486	###	-0.743	0.212
Coefficient values for Rice In Cherukupalli Mandal (Rabi)							

Case 1	-7401.063	1.542	-15.109	465.175	0.893	-0.883	0.531
Case 2	-7369.758	###	-15.109	465.175	0.893	-0.883	0.531
Case 3	-9070.777	1.070	-29.301	490.518	1.938	###	0.501
Case 4	-5743.198	1.754	-22.713	449.452	###	-1.309	0.518
Coefficient values for Rice In Nagaram Mandal (Kharif)							
Case 1	2692.010	1.713	-119.941	198.857	0.176	-0.512	0.216
Case 2	2918.808	###	-119.941	198.857	0.176	-0.512	0.216
Case 3	520.205	1.815	-97.667	229.090	0.558	###	0.208
Case 4	2815.268	1.788	-112.613	193.147	###	-0.635	0.215
Coefficient values for Rice In NagaramMandal (Rabi)							
Case 1	-7263.373	0.679	-11.545	449.970	0.970	-0.821	0.521
Case 2	-7246.059	###	-11.545	449.970	0.970	-0.821	0.521
Case 3	-8842.231	0.334	-25.969	476.567	1.937	###	0.495
Case 4	-5437.596	0.836	-19.276	431.020	###	-1.283	0.506

In the Bhattiprolu mandal when the yields are kept constant in Kharif season all the variables showed direct impact except maximum temperature which showed negative impact.Whereas in Rabi season the R^2 value is 56.3%, which implies that in the Rabi season the area sown under Rice crop is low.It is similar with Kollur mandal whereas in the mandals of Vemur, Repalle, Cherukupalli and Nagaram have shown different R^2 values. In the kharif season except maximum temperature all the other parameters have direct impact on the crop yield which is shown in all the mandals.All the above said mandals in the Rabi season have positive values under various parameters except maximum temperature.From the above analysis all the mandals have shown less than 60% R^2 values, hence the model is inadequate to explain variation and hence such models cannot be recommended for forecasting.

Table-4.20 Findings of Fitted Models through Ordinary Least Square Method – Guntur District

Commodities	Prices, Rainfall, Production			GDP, Prices, Rainfall Production	
	Observations	Multiple R	R Square	Multiple R	R Square
Rice	25	0.420	0.177	0.865	0.748
Maize	25	0.924	0.854	0.870	0.757
Chillies	25	0.620	0.384	0.843	0.711
Groundnut	25	0.527	0.277	0.841	0.707

The above table-4.20 shows the R-square and multiple-R values for the district of Guntur. (1) When prices, rainfall and production were taken the R-square value varied from 0.85 for maize and 0.17 for Rice, (2) Whereas with the parameters like GDP, Prices, rainfall and production the R-square values varied from 0.75 for Maize to 0.70 for Groundnut.The OLS model with GDP, prices, rainfall and production showed 99% accuracy and error in prediction is 1%.Thereby the study shows that there is direct impact of rainfall over production and prices of all the four crops taken for study in Guntur district.

KRISHNA DISTRICT

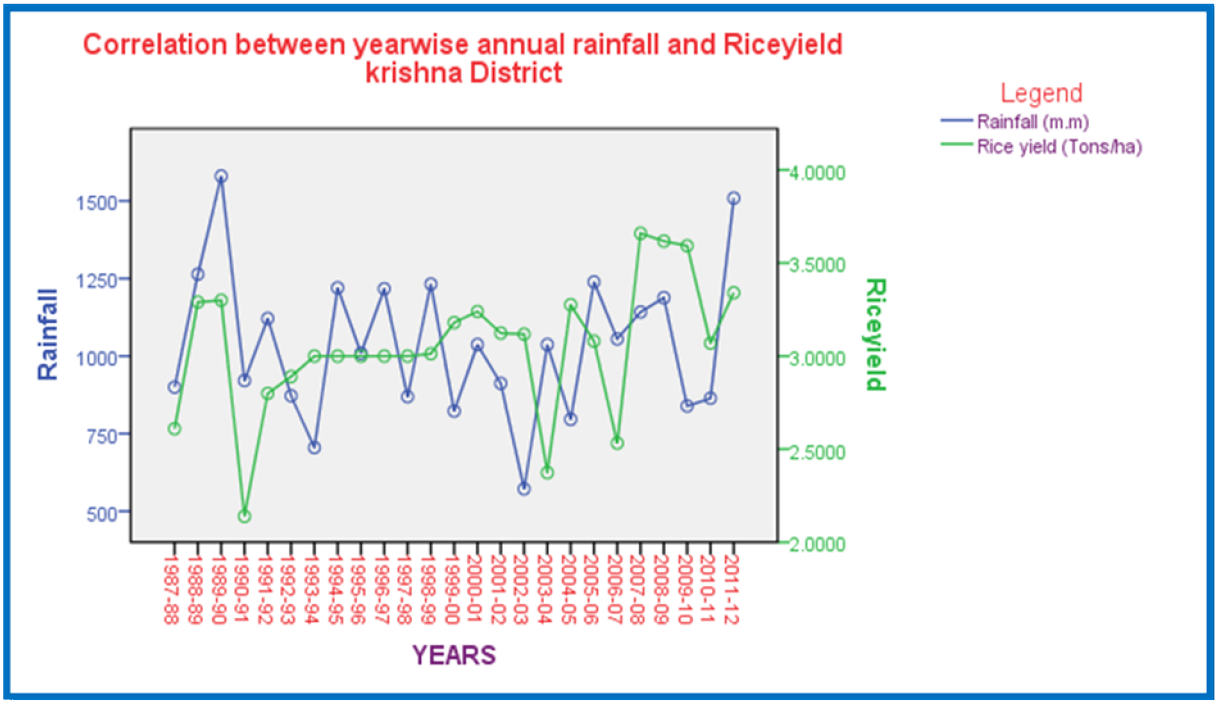
This district has been selected to study the impact of climate change on agricultural productivity.Based on the coefficient of variance values (coefficient of variance between annual and normal rainfall) five mandals were identified for a detailed study of the correlation between rainfall and crop yield.Out of these mandals Goburu and Movva displayed high coefficient of variance, while Ghantasala, Machilipatnam and Challapalli displayed low coefficient of variance.The facts are highlighted in the table-4.21 given below.

Table-4.21 MANDALS CHOSEN FOR DETAILED ANALYSIS IN KRISHNA DISTRICT

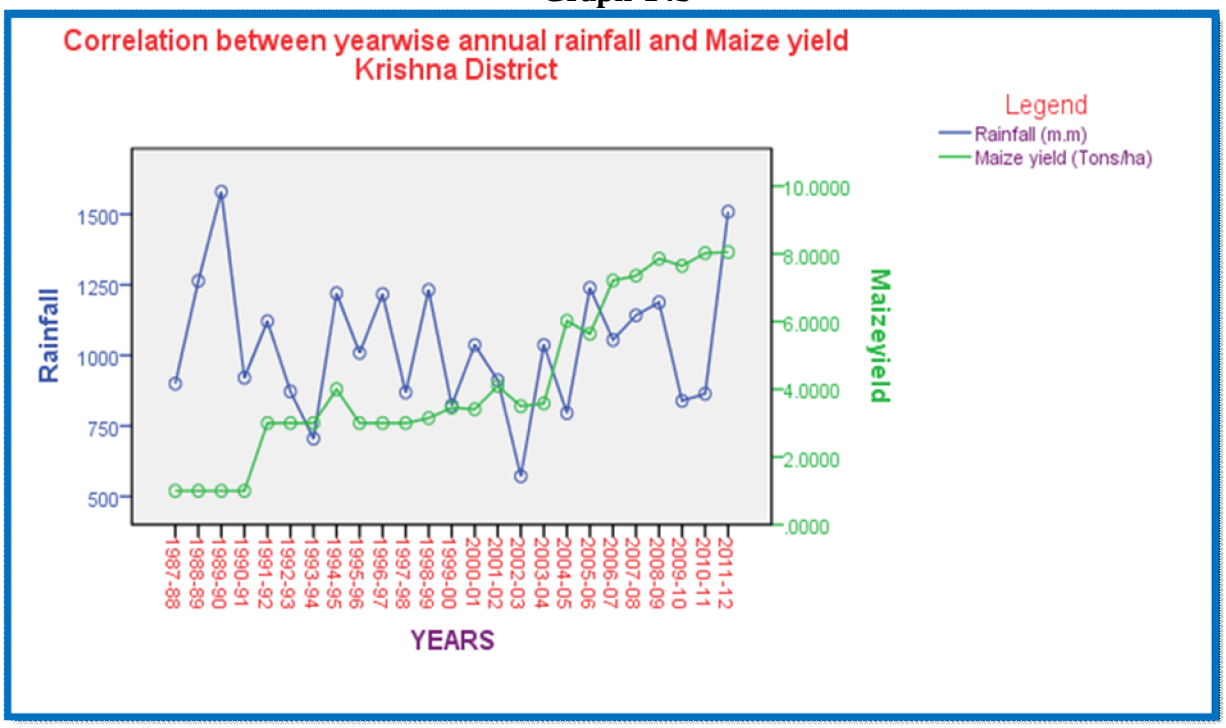
S.No.	Mandals	Annual Rainfall	Normal Rainfall	CoV	Percentage Deviation	R^2 Values
	KRISHNA ZONE					
1	MOVVA	1006.71	1001.80	52.27	0.50	0.04
2	GHANTASALA	868.14	973.30	44.44	-10.80	0.04
3	CHALLAPALLI	1153.96	1164.40	37.46	-0.90	0.10
4	GUDURU	662.81	1109.30	90.84	-40.25	0.64
5	MACHILIPATNAM	1106.28	1125.40	40.20	-1.70	0.005

Further a correlation analysis between the crop yield and Rainfall is carried out for the four major crops of the district.The (graph-14 (a) to 14 (d)) gives a clear picture about the relationship between crop yield and rainfall.

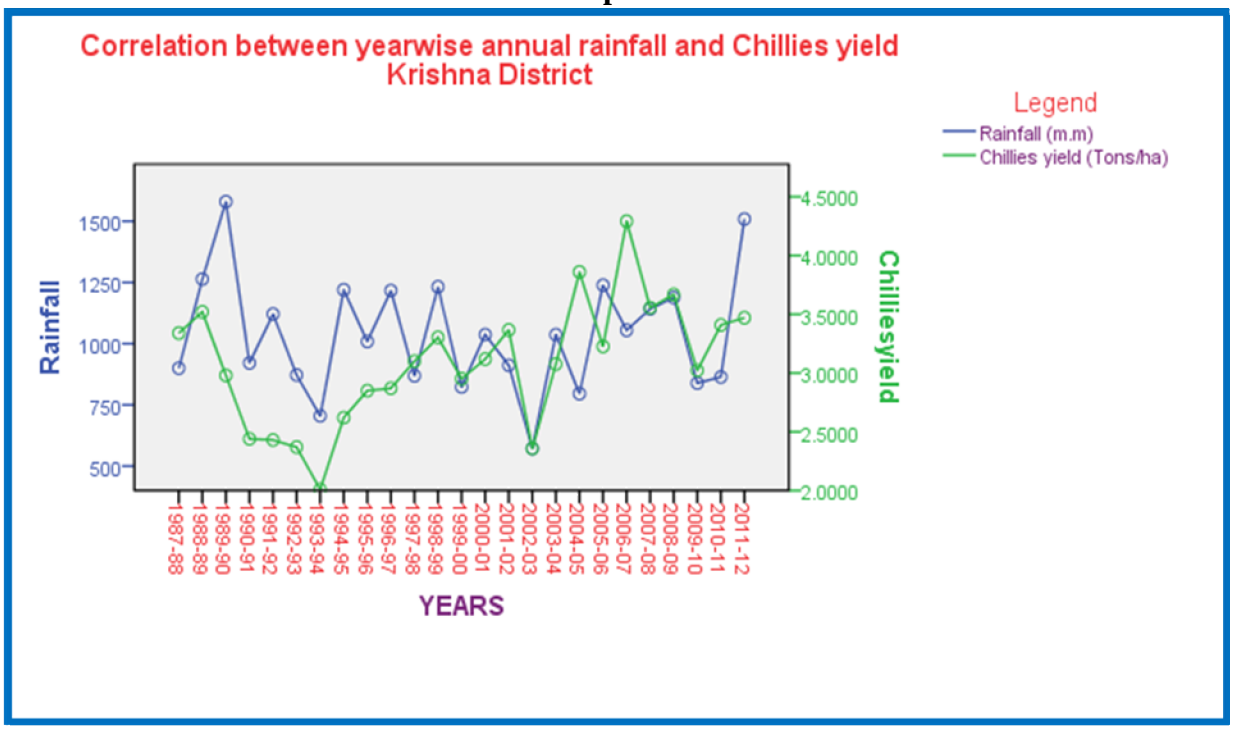
Graph-14a


Correlation between yearwise annual rainfall and Riceyield
krishna District
Legend
Rainfall (m.m)
Rice yield (Tons/ha)
Rainfall
Riceyield
YEARS
1500
1250
1000
750
500
4.0000
3.5000
3.0000
2.5000
2.0000
1987-88
1988-89
1989-90
1990-91
1991-92
1992-93
1993-94
1994-95
1995-96
1996-97
1997-98
1998-99
1999-00
2000-01
2001-02
2002-03
2003-04
2004-05
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12

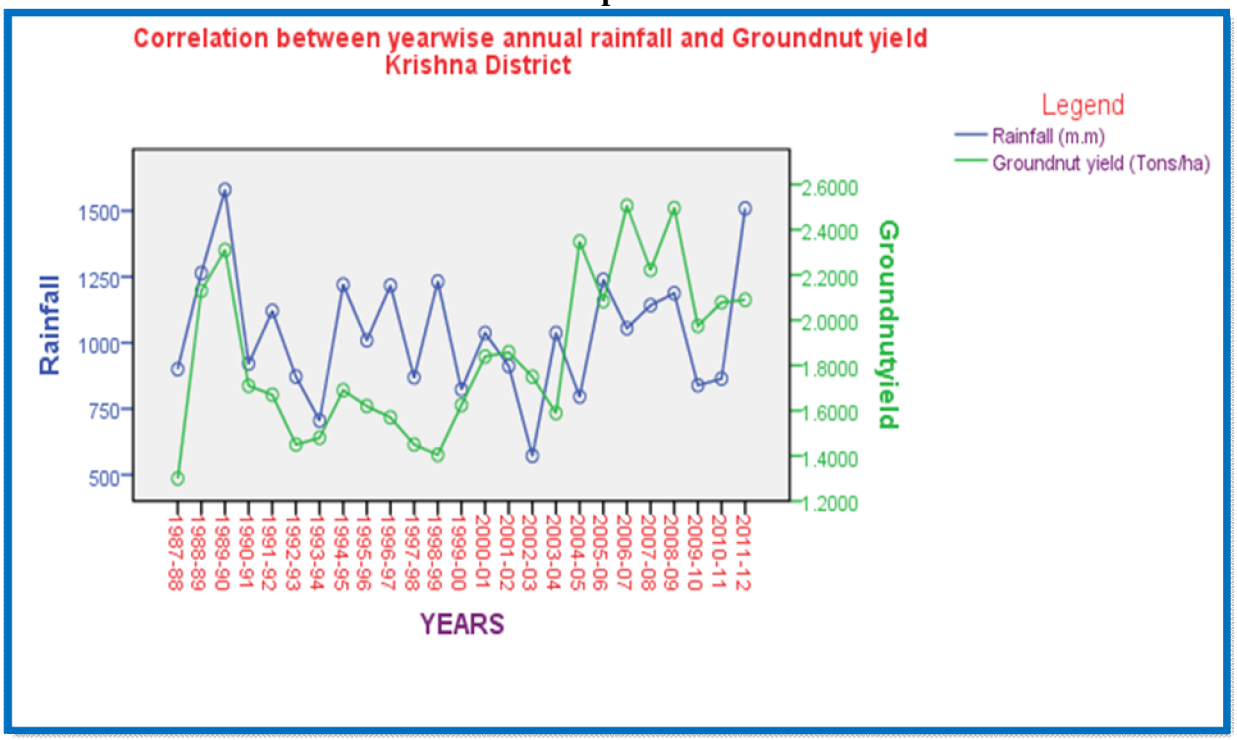
Graph-14b


Correlation between yearwise annual rainfall and Maize yield
Krishna District
Legend
Rainfall (m.m)
Maize yield (Tons/ha)
Rainfall
Maizeyield
YEARS
1500
1250
1000
750
500
10.0000
8.0000
6.0000
4.0000
2.0000
.0000
1987-88
1988-89
1989-90
1990-91
1991-92
1992-93
1993-94
1994-95
1995-96
1996-97
1997-98
1998-99
1999-00
2000-01
2001-02
2002-03
2003-04
2004-05
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12

Graph-14c



Graph-14d



For the crops Rice and Maize there is no direct relationship between the rainfall and the yield. Though, there is an increase in rainfall, the yield did not show any increase. For the crops Chillies and Groundnut between the years 2003 – 2008, though the rainfall recorded low, yet the yield was more.This shows that other sources of water and fertilizers might have been used so that the yields have gone up.In the years between 2010 and– 2012, the rainfall recorded was high but the yield was less for both the crops.The reasons may be that the area under the crop sown could have come down.

Using the regression analysis R^2 values were computed for the four crops of the district.The variables taken for the analysis were average rainfall, temperature, fertilizers and human labour. The R^2 value is 40.6 for Rice when all the parameters were taken and these variables except minimum temperature have shown positive impact on the crop yield.For the Maize crop rainfall and minimum temperatures showed negative impact on the crop yield and the R^2 value showed 95.1%. For Chillies, the rainfall and maximum temperature showed negative values and the R^2 values for this crop is 43.1%. The R^2 value for Groundnut is 42.1; even this crop has no direct relation with rainfall and maximum temperature.If the R^2 values are less than 60%, the model is inadequate to explain the variation in the given set of dependent variable data. Hence such models cannot be recommended for forecasting.

Table-4.22 Regression Values for the four crops for the period 1988 – 2012 in Krishna District.

Cases	Constant	Act-avg	Max-tem	Min-tem	Fertilizers	Humanlabour	R^2
Coefficient values for Rice							
Case 1	-5511.019	0.578	431.228	-275.799	0.788	-0.190	0.406
Case 2	-4908.710	###	431.031	-275.717	0.788	-0.190	0.406
Case 3	-6413.325	0.580	444.692	-269.592	0.964	###	0.405
Case 4	-5334.355	0.640	449.462	-277.368	###	-0.469	0.398
Coefficient values for Maize							
Case 1	7662.750	-0.291	589.735	-668.569	10.252	-9.944	0.951
Case 2	7381.796	###	589.248	-668.700	10.254	-9.945	0.951
Case 3	-22239.131	0.333	1053.525	-855.918	19.269	###	0.912
Case 4	-588.685	0.106	905.877	-189.245	###	-15.898	0.925
Coefficient values for Chilies							
Case 1	734.797	-0.495	-60.012	57.237	5.536	-0.085	0.431
Case 2	209.627	###	-59.507	57.157	5.532	-0.085	0.431
Case 3	429.047	-0.491	-57.300	63.983	5.476	###	0.431
Case 4	-17136.585	0.159	372.765	268.823	###	1.343	0.281
Coefficient values for Groundnut							
Case 1	300.949	0.119	-16.007	215.804	-3.924	-2.714	0.421
Case 2	422.764	###	-15.986	215.806	-3.924	-2.713	0.421
Case 3	-10589.099	0.441	257.956	160.181	-1.636	###	0.341
Case 4	974.739	0.103	-28.482	146.448	###	-1.891	0.380

An Analysis of regression coefficient for Rice crop in Kharif and Rabi seasons in the five selected mandals of the district is given in the below table-4.23, unlike at the district level the selected individual mandals showed a direct relationship of the variables such as actual rainfall and temperature on the Rice crop in both Kharif and Rabi seasons.

Table-4.23 Regression Values for Rice in Kharif and Rabi Seasons in Krishna District

Cases	Constant	Act-avg	Max-tem	Min-tem	Fertilizers	Humanlabour	R^2
Coefficient values for Rice In Challapalli Mandal (Kharif)							
Case 1	2890.447	0.766	85.415	-129.937	1.507	-0.561	0.220
Case 2	3000.101	###	85.415	-129.937	1.507	-0.561	0.220
Case 3	363.354	1.238	123.554	-106.357	1.726	###	0.207
Case 4	1843.945	1.477	148.100	-122.674	###	-0.758	0.190
Coefficient values for Rice In Challapalli Mandal (Rabi)							
Case 1	-4316.426	4.229	296.202	-169.713	2.350	-0.793	0.370
Case 2	-4185.425	###	296.202	-169.713	2.350	-0.793	0.370
Case 3	-6875.028	4.048	305.762	-137.064	3.313	###	0.336
Case 4	2164.479	4.293	147.238	-128.569	###	-1.488	0.298
Coefficient values for Rice In Ghantasala Mandal (Kharif)							
Case 1	-1017.659	2.749	199.527	-126.323	0.892	-0.111	0.280
Case 2	-702.424	###	199.527	-126.323	0.892	-0.111	0.280
Case 3	-1540.644	2.858	208.169	-122.002	0.932	###	0.279
Case 4	-1708.735	3.202	239.946	-122.989	###	-0.226	0.269
Coefficient values for Rice In Ghantasala Mandal (Rabi)							
Case 1	-6137.554	5.644	325.007	-148.346	2.694	-0.725	0.391
Case 2	-5986.578	###	325.007	-148.346	2.694	-0.725	0.391
Case 3	-8539.492	5.557	335.752	-118.841	3.572	###	0.363
Case 4	1644.919	5.262	144.912	-102.346	###	-1.509	0.297
Coefficient values for Rice In Machilipatnam Mandal (Kharif)							
Case 1	3768.453	0.254	64.388	-133.490	1.658	-0.718	0.215
Case 2	3805.843	###	64.388	-133.490	1.658	-0.718	0.215
Case 3	920.245	0.387	95.021	-100.193	2.213	###	0.190
Case 4	2758.921	0.830	136.039	-128.471	###	-1.061	0.179
Coefficient values for Rice In Machilipatnam Mandal (Rabi)							
Case 1	-3986.274	4.492	285.323	-176.513	2.506	-0.666	0.400
Case 2	-3895.313	###	285.323	-176.513	2.506	-0.666	0.400
Case 3	-6269.088	4.493	297.068	-149.173	3.318	###	0.376
Case 4	3034.251	4.402	123.130	-132.264	###	-1.404	0.318
Coefficient values for Rice In Movva Mandal (Kharif)							
Case 1	4430.455	-0.035	42.166	-134.079	1.831	-0.740	0.213
Case 2	4426.283	###	42.166	-134.079	1.831	-0.740	0.213
Case 3	1707.487	0.008	66.136	-99.619	2.461	###	0.187

Case 4	3487.549	0.699	116.904	-130.634	###	-1.105	0.175
Coefficient values for Rice In Movva Mandal (Rabi)							
Case 1	-4337.550	3.875	294.754	-165.681	2.305	-0.770	0.347
Case 2	-4224.389	###	294.754	-165.681	2.305	-0.770	0.347
Case 3	-6823.432	3.712	304.078	-134.102	3.243	###	0.315
Case 4	1958.718	3.997	150.384	-125.349	###	-1.452	0.277
Coefficient values for Rice In Guduru Mandal (Kharif)							
Case 1	655.233	1.837	163.449	-149.312	0.912	0.002	0.290
Case 2	921.065	###	163.449	-149.312	0.912	0.002	0.290
Case 3	661.528	1.836	163.349	-149.359	0.912	###	0.290
Case 4	313.466	2.108	196.690	-149.399	###	-0.119	0.278
Coefficient values for Rice In Guduru Mandal (Rabi)							
Case 1	-2735.936	6.421	273.937	-202.686	1.908	-0.481	0.327
Case 2	-2595.632	###	273.937	-202.686	1.908	-0.481	0.327
Case 3	-4445.870	6.791	286.705	-185.674	2.452	###	0.315
Case 4	2110.558	7.365	167.951	-176.362	###	-0.994	0.281

Table-4.24 Findings of Fitted Models through Ordinary Least Square Method – Krishna District

Commodities	Prices, Rainfall, Production			GDP, Prices, Rainfall Production	
	Observations	Multiple R	R Square	Multiple R	R Square
Rice	25	0.074	0.005	0.790	0.624
Maize	25	0.946	0.894	0.716	0.512
Chillies	25	0.299	0.090	0.665	0.442
Groundnut	25	0.767	0.589	0.677	0.458

The findings through ordinary least square method (OLS) are shown in the above table-4.24 that reveals the R-square values varied from 0.62 to 0.44.The findings show that production and prices were affected by variations in the amount of rainfall received.

RAYALASEEMA REGION

The two districts which were selected for the study are Kurnool and Ananthapur.These districts are in scarce Rainfall – Agroclimatic zone.From each of these districts four mandals were considered for an exhaustive study of the correlation between rainfall and crop yield.

ANANTHAPUR DISTRICT

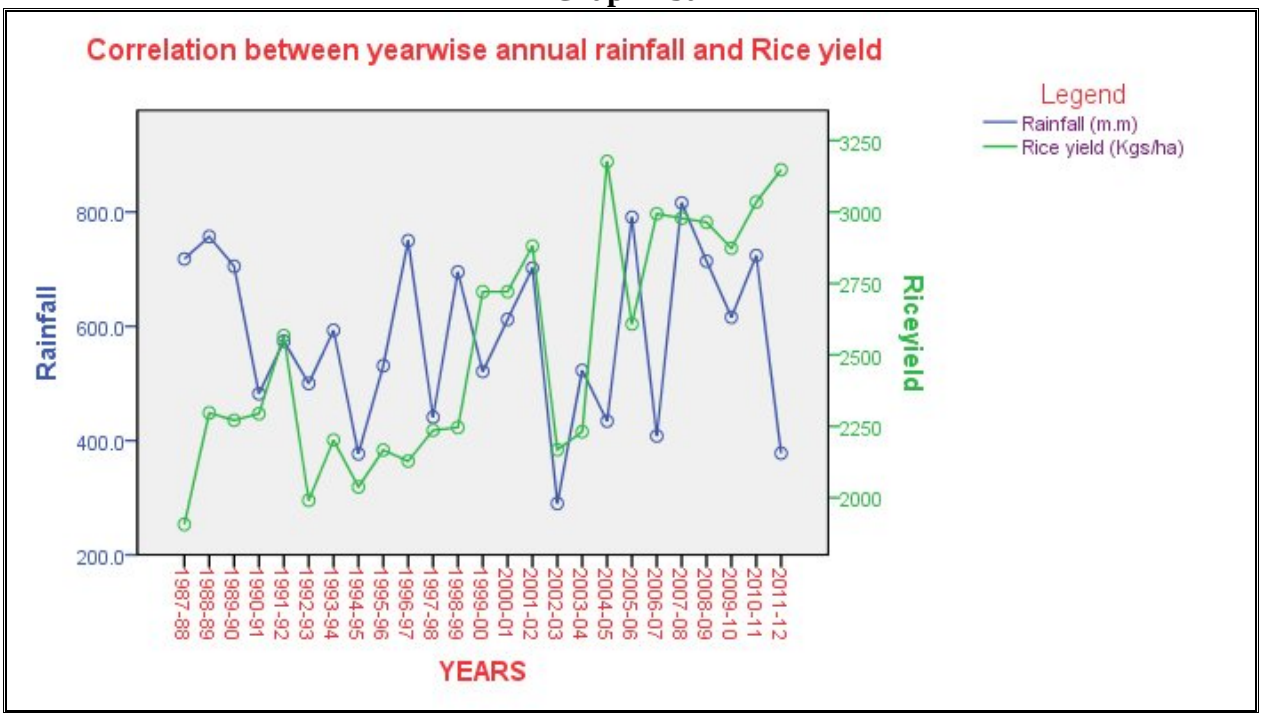
The mandals selected in the district are Yadiki, Puttur, Narpala and Talupula. They fall under the scarce rainfall zone. The following table-4.25 shows the coefficient of variance (COV) values and other rainfall details for these mandals.

Table-4.25MANDALS CHOSEN FOR DETAILED ANALYSIS IN ANANTHAPUR DISTRICT

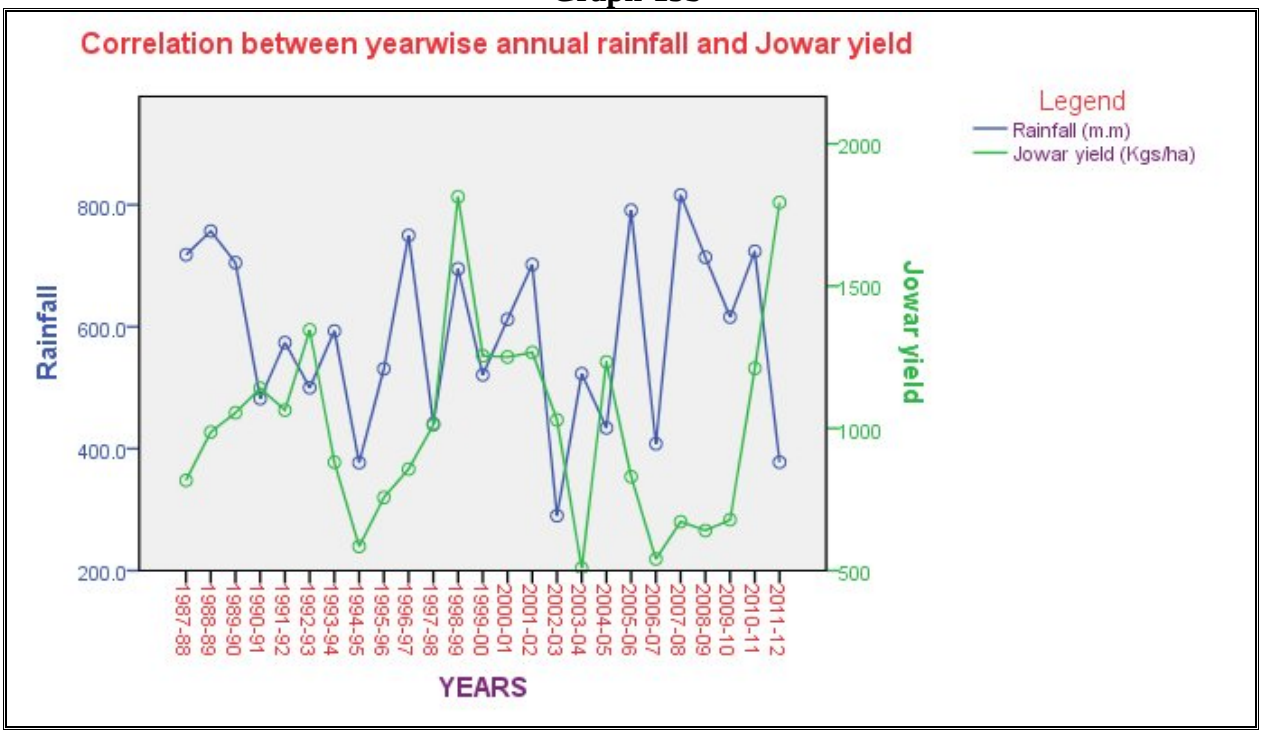
S.No.	Mandals	Annual Rainfall	Normal Rainfall	CoV	Percentage Deviation	R^2 Values
	SCARCE RAINFALL ZONE					
1	YADIKI	503.36	646.0	56.90	-22.1	0.03
2	NARPALA	487.49	576.4	58.48	-15.4	0.06
3	PUTLUR	586.33	563.1	24.84	4.1	0.00
4	TALUPULA	627.19	636.2	25.00	-1.4	0.00

The graphs-15(a) to 15(d) show the correlation between crop yield and rainfall.The graphs for Rice and Groundnut showed direct relationship between rainfall recorded and crop yields.The Jowar crop and Redgram showed erratic relationship.

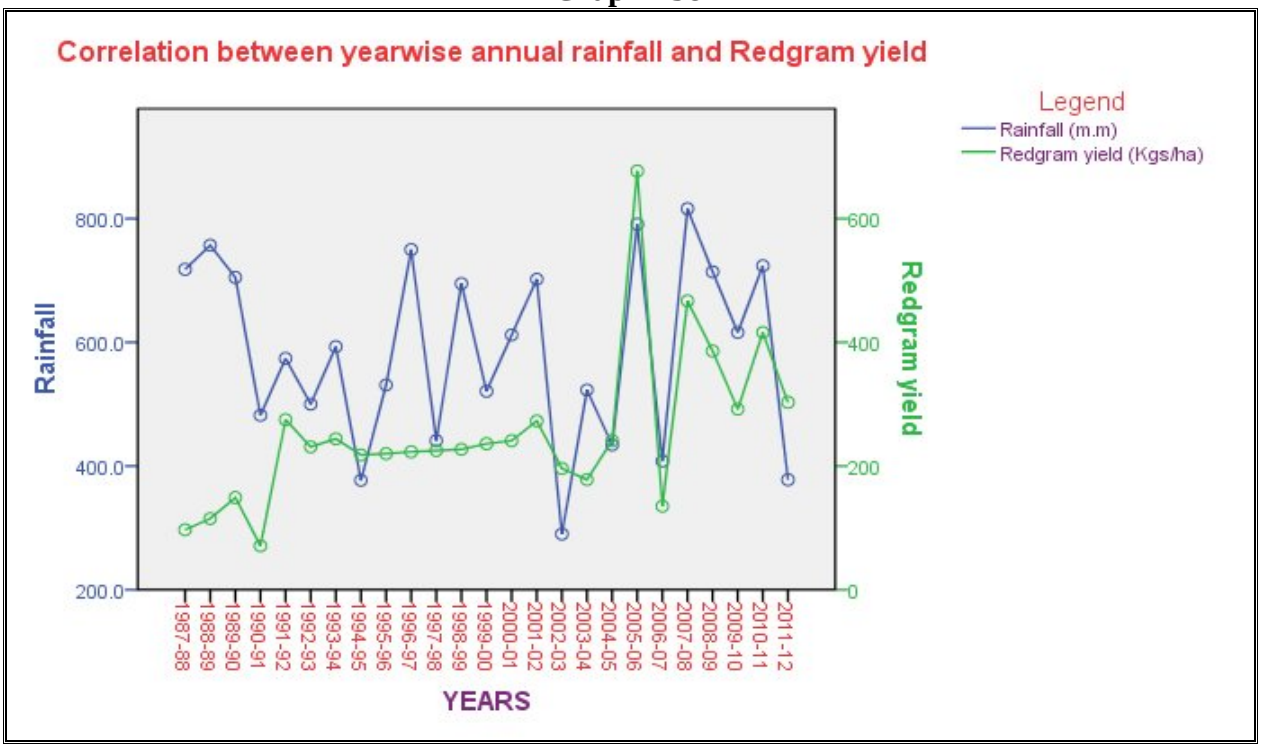
Graph-15a



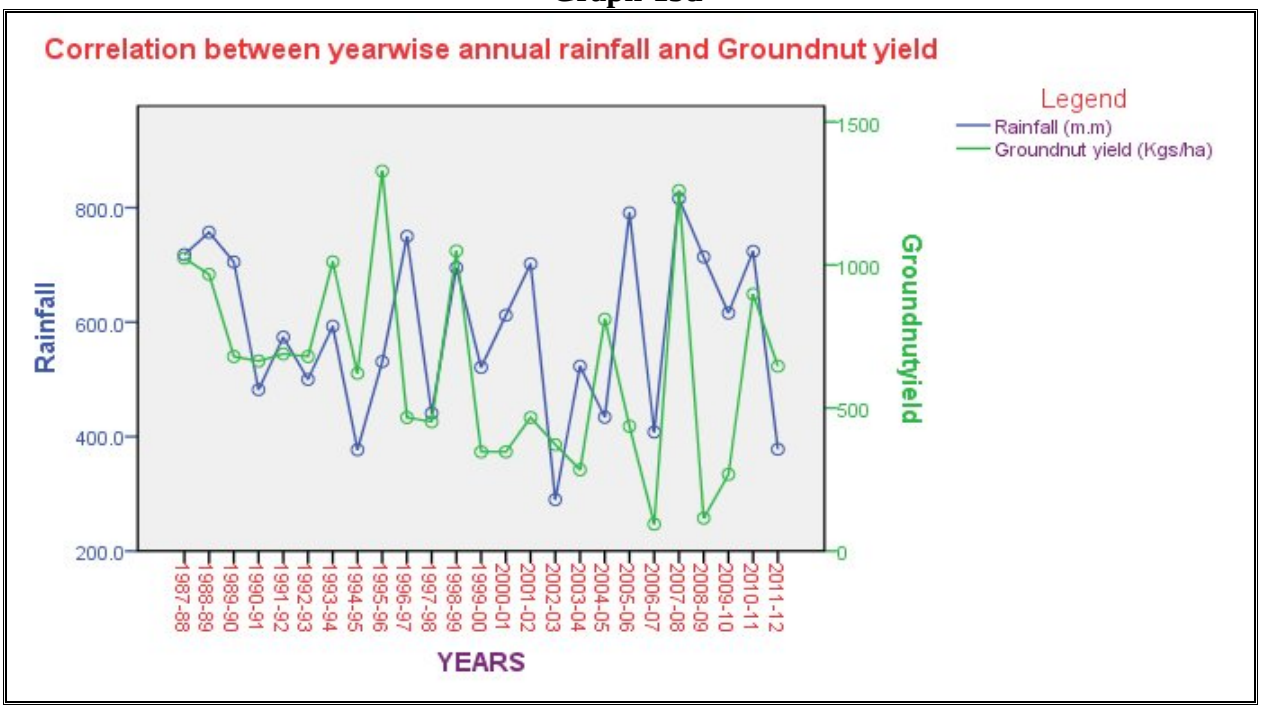
Graph-15b



Graph-15c



Graph-15d



Further a regression analysis is computed for the four major crops of the district.The major crops taken are Rice, Jowar, Redgram and Groundnut. The district wise analysis reveals that the R^2 value are above 60% for the crops like Rice and Redgram, whereas crops such as Jowar and Redgrams showed R^2 values below 60%, this is highlighted in the following table-4.26

Table-4.26 Regression Values for the four crops for the period 1988 – 2012 in Ananthpur District.

District Level Coefficient Values							
Cases	**Constant**	**Act-avg**	**Max-tem**	**Min-tem**	**Fertilizers**	**Humanlabour**	**R^2**
Coefficient values for Rice							
Case 1	3949.606	.510	74.613	-228.354	2.349	-0.193	.694
Case 2	3447.490	.527	86.629	-237.867	2.535	###	.693
Case 3	5535.175	0.483	###	-202.827	2.784	###	.682
Case 4	6494.251	###	###	-231.354	2.651	###	.561
Coefficient values for jowar							
Case 1	10776.370	-.379	-97.298	32.964	-44.548	-22.516	.153
Case 2	10847.338	-.393	-79.105	###	-44.633	-22.185	.151
Case 3	7374.903	**-.339**	###	###	-40.017	-19.682	.137
Case 4	8108.259	###	###	###	-46.116	-22.566	.124
Coefficient values for Redgram							
Case 1	208.675	-.462	42.366	-90.386	19.505	2.871	.679
Case 2	1295.579	-.479	###	-69.625	18.735	2.381	.657
Case 3	1504.496	-.346	###	-55.548	8.637	###	.623
Case 4	210.229	-.310	###	###	10.808	###	.556
Coefficient values for Ground Nut							
Case 1	2702.959	.450	50.868	-155.819	-6.439	.341	.445
Case 2	3200.647	.502	43.616	-145.723	-7.813	###	.442
Case 3	4292.129	.473	###	-129.550	-7.452	###	.438
Case 4	5066.825	###	###	-152.143	-7.528	###	.309

The regression analysis is also calculated for Rice crop in Kharif and Rabi season for the selected four mandals of the district.The following table-4.27 gives a detailed account of R^2 values for the Rice crop in the mandals.

Table-4.27 Regression Values for Rice in Kharif and Rabi Seasons in Ananthapur District

Coefficient values for Kharif and Rabi							
Cases	**Constant**	**Act-avg**	**Max-tem**	**Min-tem**	**Fertilizers**	**Humanlabour**	**R^2**
Coefficient values for Kharif Rice Yadiki							
Case 1	9033.412	-.600	-163.792	10.946	2.503	-2.009	.660
Case 2	8967.247	-.581	-155.179	###	2.498	-1.977	.656
Case 3	7887.933	###	-127.338	###	2.602	-1.890	.653

Case 4	3442.978	###	###	###	2.794	-1.648	.636
Coefficient values for Rabi Rice Yadiki							
Case 1	1807.089	1.352	111.737	-149.519	2.755	-.904	.677
Case 2	1984.007	###	106.551	-152.437	2.860	-.853	.676
Case 3	1212.807	###	117.223	-191.926	3.657	###	.666
Case 4	4489.061	###	###	-148.398	3.909	###	.646
Coefficient values for Kharif Rice Putlur							
Case 1	7528.860	.349	-117.996	.839	2.599	-1.884	.654
Case 2	7523.798	.352	-117.332	###	2.599	-1.882	.654
Case 3	7887.933	###	-127.338	###	2.602	-1.890	.653
Case 4	3442.978	###	###	###	2.794	-1.648	.636
Coefficient values for Rabi Rice Putlur							
Case 1	1475.034	1.941	120.328	-154.573	2.837	-.830	.678
Case 2	1984.007	###	106.551	-152.437	2.860	-.853	.676
Case 3	1212.807	###	117.223	-191.926	3.657	###	.666
Case 4	4489.061	###	###	-148.398	3.909	###	.646
Coefficient values for Kharif Rice Narpala							
Case 1	7262.208	.678	-108.339	.943	2.551	-1.924	.658
Case 2	7258.843	.679	-107.654	###	2.550	-1.921	.658
Case 3	7887.933	###	-127.338	###	2.602	-1.890	.653
Case 4	3442.978	###	###	###	2.794	-1.648	.536
Coefficient values for Rabi Rice Narpala							
Case 1	1822.301	.824	109.946	-150.119	2.819	-.863	.677
Case 2	1984.007	###	106.551	-152.437	2.860	-.853	.676
Case 3	1212.807	###	117.223	-191.926	3.657	###	.666
Case 4	4489.061	###	###	-148.398	3.909	###	.646
Coefficient values for Kharif Rice Talupula							
Case 1	5559.571	1.978	-61.206	-30.301	3.190	-1.504	.665
Case 2	5898.492	1.756	-87.602	###	3.143	-1.617	.664
Case 3	2655.794	2.294	###	###	3.423	-1.391	.657
Case 4	3442.978	###	###	###	2.794	-1.648	.636
Coefficient values for Rabi Rice Talupula							
Case 1	2509.980	-2.100	94.463	-154.107	2.954	-.884	.678
Case 2	1984.007	###	106.551	-152.437	2.860	-.853	.676
Case 3	1212.807	###	117.223	-191.926	3.657	###	.666

Table-4.28 Findings of Fitted Models through Ordinary Least Square Method – Ananthapur District

Commodities	Prices, Rainfall, Production			GDP, Prices, Rainfall Production	
	Observations	Multiple R	R Square	Multiple R	R Square
Rice	25	0.194	0.038	0.689	0.475
Red Gram	25	0.274	0.075	0.685	0.469
Jowar	25	0.533	0.284	0.703	0.494
Groundnut	25	0.362	0.131	0.748	0.559

Using ordinary least square method the R^2 values for the four crops of the district were computed without GDP the R^2 values varied between 0.28-0.03, whereas with GDP the R^2 values varied between 0.56 to 0.47.This method is used to read the impact of rainfall on agricultural productivity and prices. The impact of climate change on agricultural productivity is direct in the case of Groundnut crop whereas mixed response is seen for Jowar, Redgram and Rice.

KURNOOL DISTRICT

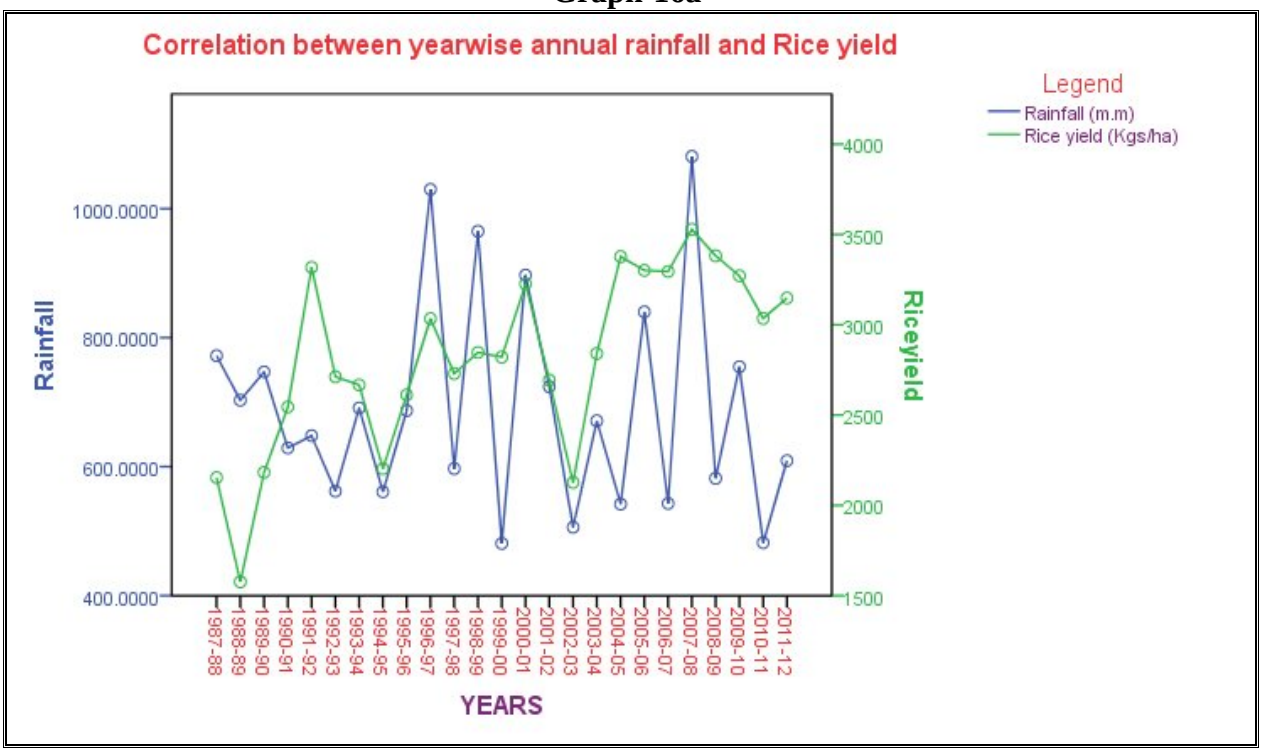
The four mandals are Kallur, Adoni, Veldurthi and Mahanandi.Kallur and Mahanandi showed high coefficient of variance and the mandals of Adoni and Veldurthi have shown low coefficient of variance.The details of these mandals are highlighted in the following table-4.29

Table-4.29MANDALS CHOSEN FOR DETAILED ANALYSIS IN KURNOOL DISTRICT

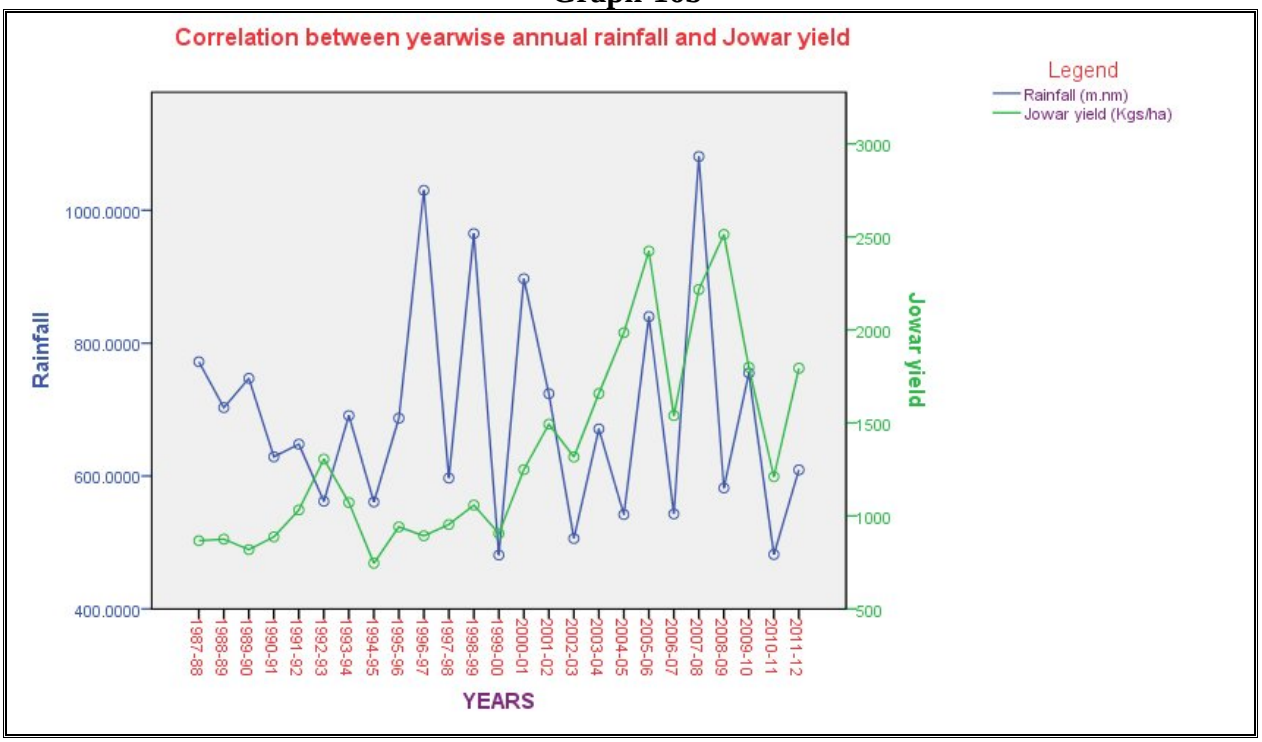
S.No.	Mandals	Annual Rainfall	Normal Rainfall	CoV	Percentage Deviation	R^2 Values
	SCARCE RAINFALL ZONE					
1	KALLUR	612.52	714.8	51.08	-13.4	0.10
2	ADONI	684.85	663.8	23.50	3.2	0.02
3	VELDURTHI	609.01	583.0	23.81	4.5	0.01
4	MAHANANDI	727.80	809.6	55.80	-10.1	0.18

The graphs for the crops Rice 16(a), Jowar 16(b), Redgram 16(c) and Groundnut 16(d) for the district is shown below. The graph-16 (a) for Rice shows that with the increase in rainfall the yield also increased except for the year 1990-91 and 1991-92. These years have shown a decrease in rainfall and yet the yield increased, this could be due to other source of water and fertilizers input, so the resultant increase.In the case of Jowar, both yield and rainfall recorded fluctuations from 1987-88 to 2002-03, then in the later years i.e. 2004-05 onwards as the rainfall increased the yield also increased.The graph-16(c) & 16(d) for Redgram and Groundnut showed a direct correlation between rainfall and crop yield i.e., when the rainfall recorded increased the yield also increased.

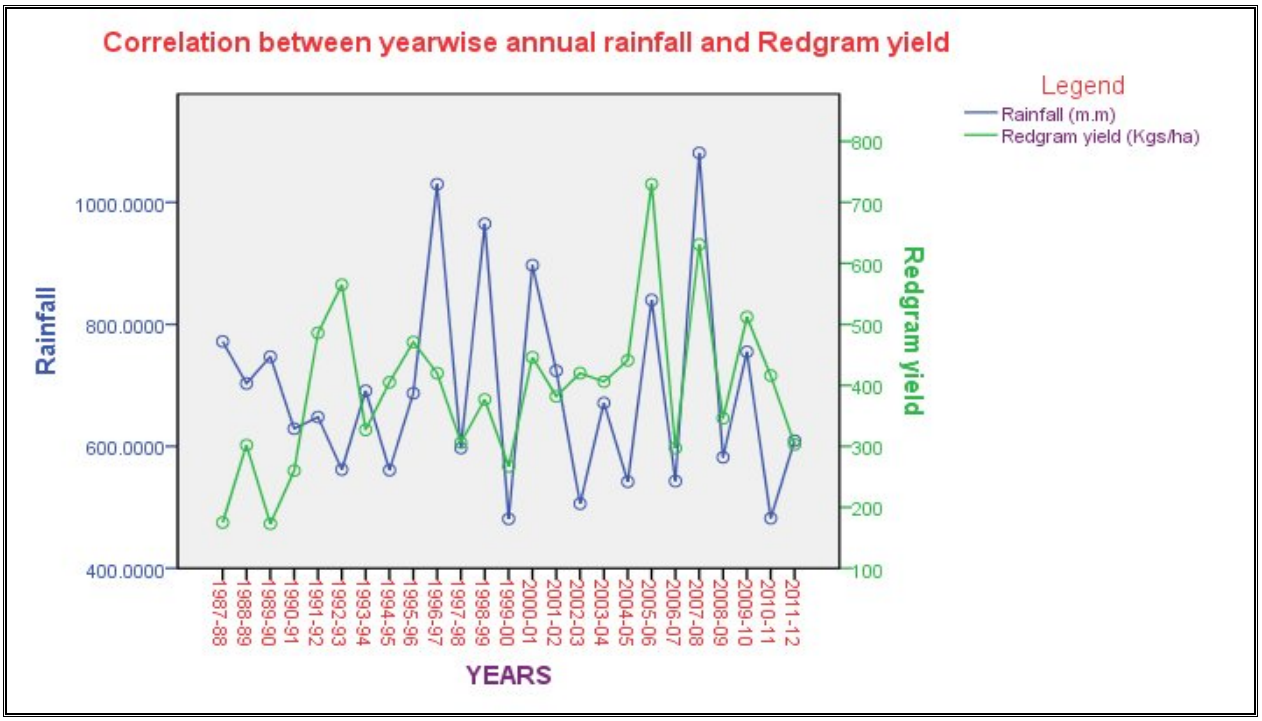
Graph-16a



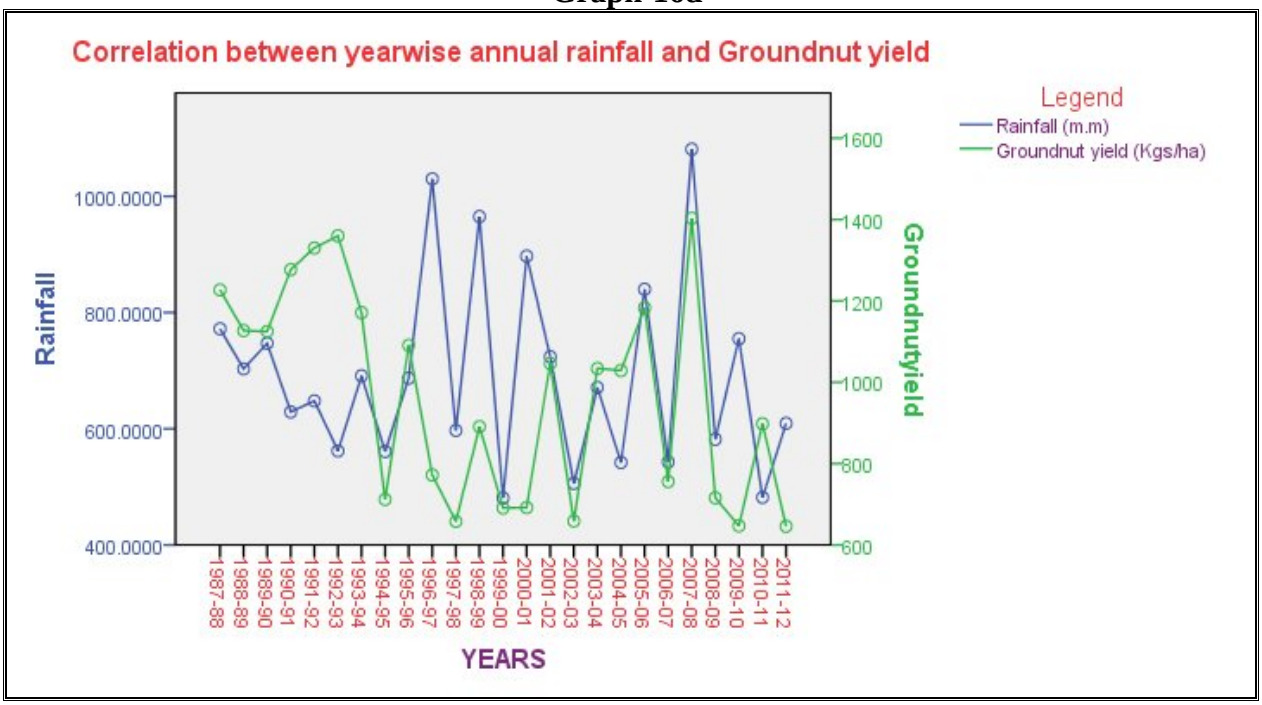
Graph-16b



Graph-16c


Correlation between yearwise annual rainfall and Redgram yield
Legend
Rainfall (m.m)
Redgram yield (Kgs/ha)
Rainfall
Redgram yield
YEARS

Graph-16d


Correlation between yearwise annual rainfall and Groundnut yield
Legend
Rainfall (m.m)
Groundnut yield (Kgs/ha)
Rainfall
Groundnutyield
YEARS

The district wise regression analysis for the four crops is given in the following table-4.30. The crops such as Rice, Jowar and Groundnut showed R^2 value above 60%, whereas redgram showed less than 60% R^2 value, which indicates that this analysis is adequate to explain the variations between rainfall and crop yield.

Table-4.30 Regression Values for the four crops for the period 1988 – 2012 in Kurnool District.

District Level Coefficient Values							
Cases	**Constant**	**Act-avg**	**Max-tem**	**Min-tem**	**Fertilizers**	**Humanlabour**	**R^2**
Coefficient values for Rice							
Case 1	10076.471	.182	-183.631	7.298	2.435	-2.021	.610
Case 2	10127.837	.186	-179.987	###	2.427	-2.029	.610
Case 3	11282.702	###	-207.527	###	2.438	-2.105	.601
Case 4	3440.232	###	###	###	2.795	-1.646	.581
Coefficient values for Jowar							
Case 1	8790.992	-.462	-361.317	306.013	1.103	-10.488	.629
Case 2	9098.856	-.466	-365.322	306.243	###	-11.041	.629
Case 3	7015.655	###	-277.710	248.069	###	-10.579	.613
Case 4	8559.719	###	-155.594	###	###	-11.116	.590
Coefficient values for Redgram							
Case 1	4845.251	-.125	-71.181	27.999	-14.698	-8.937	.533
Case 2	4905.866	-.108	-54.996	###	-14.594	-8.925	.529
Case 3	3944.692	###	-36.668	###	-13.094	-8.042	.416
Case 4	2268.267	###	###	###	-10.533	-6.707	.408
Coefficient values for Ground Nut							
Case 1	11382.358	-.522	-195.914	-55.402	-8.546	-.904	.618
Case 2	11175.933	-.554	-227.799	###	-8.413	-.857	.614
Case 3	9787.432	-.511	-226.080	###	-4.716	###	.575

The regression analysis for Rice crop in both Kharif and Rabi season for all the selected mandals were computed.The R^2 values for all the mandals were above 60%.This is shown in the following table-4.31

Table-4.31 Regression Values for Rice in Kharif and Rabi Seasons in Kurnool District

Coefficient values for Kharif and Rabi							
Cases	**Constant**	**Act-avg**	**Max-tem**	**Min-tem**	**Fertilizers**	**Humanlabour**	**R2**
Coefficient values for Kharif Rice Kallur							
Case 1	4676.213	1.182	-199.993	252.304	1.691	-1.759	.632
Case 2	5753.636	1.845	-179.098	237.402	###	-2.425	.621
Case 3	1395.031	2.152	###	162.551	###	-2.205	.592
Case 4	5476.152	1.863	###	###	###	-2.530	.576

Coefficient values for Rabi Rice Kallur							
Case 1	5046.916	-8.914	-57.493	-9.437	4.684	-1.577	.593
Case 2	5093.022	-9.167	-64.962	###	4.722	-1.579	.593
Case 3	2506.400	-8.181	###	###	4.679	-1.493	.587
Case 4	3340.232	###	###	###	2.795	-1.646	.553
Coefficient values for Kharif Rice Mahanandi							
Case 1	10876.478	.071	-217.332	29.196	2.469	-2.054	.577
Case 2	10969.457	###	-220.049	29.961	2.469	-2.063	.577
Case 3	11282.702	###	-207.527	###	2.438	-2.105	.577
Case 4	3440.232	###	###	###	2.795	-1.646	.553
Coefficient values for Rabi Rice Mahanandi							
Case 1	9320.834	3.270	-169.463	16.306	2.439	-1.989	.583
Case 2	9465.393	3.320	-161.961	###	2.422	-2.011	.583
Case 3	11182.702	###	-207.527	###	2.438	-2.105	.577
Case 4	3340.232	###	###	###	2.795	-1.646	.553
Coefficient values for Kharif Rice Adoni							
Case 1	10030.071	1.379	-197.849	28.605	2.449	-1.995	.589
Case 2	10327.845	1.381	-185.866	###	2.420	-2.035	.588
Case 3	11282.702	###	-207.527	###	2.438	-2.105	.577
Case 4	3440.232	###	###	###	2.795	-1.646	.553
Coefficient values for Rabi Rice Adoni							
Case 1	11457.654	-.763	-234.871	30.448	2.407	-2.104	.578
Case 2	10869.457	###	-220.049	29.961	2.469	-2.063	.577
Case 3	11182.702	###	-207.527	###	2.438	-2.105	.577
Case 4	3340.232	###	###	###	2.795	-1.646	.553
Coefficient values for Kharif Rice Veldurthi							
Case 1	11541.243	1.705	-203.916	-28.343	2.504	-2.032	.588
Case 2	11246.921	1.615	-215.324	###	2.527	-1.997	.588
Case 3	11282.702	###	-207.527	###	2.438	-2.105	.577
Case 4	3440.232	###	###	###	2.795	-1.646	.553
Coefficient values for Rabi Rice Veldurthi							
Case 1	9187.999	5.658	-161.162	28.967	-2.244	1.929	.594
Case 2	9489.701	5.662	-149.016	###	1.900	-2.285	.594
Case 3	3993.406	7.137	###	###	1.990	-2.037	.583

Table-4.32 Findings of Fitted Models through Ordinary Least Square Method – Kurnool District

Commodities	Prices, Rainfall, Production			GDP, Prices, Rainfall Production	
	Observations	Multiple R	R Square	Multiple R	R Square
Rice	25	0.796	0.633	0.894	0.799
Jowar	25	0.135	0.018	0.892	0.795
Red Gram	25	0.582	0.339	0.847	0.717
Groundnut	25	0.594	0.353	0.909	0.827

The above table-4.32 shows that rainfall definitely has a direct impact on agricultural productivity. The R^2 values were computed using the ordinary least square method. Without GDP the R^2 values for the four crops varied between 0.63-0.01 and with GDP the R^2 values varied between 0.71-0.82.

CHAPTER-V
CONCLUSION

CONCLUSION

Weather and climate strongly influence agricultural productivity. To high degree farmers who adapt to the local climate in the form of established infrastructure; local farming practice and experience derived from individual practice climate change can therefore create an impact on agricultural productivity sometimes threatening established aspects of farming system but also providing opportunities for improvements.

The study clearly indicates that rainfall in Andhra Pradesh is highly variable, further the agricultural systems within the state are affected by variability in rainfall because agriculture in the state is largely dependent on rainfall.A third of the total number of districts especially the districts of coastal Andhra has high level of food grain production coupled with high levels of rainfall; however, most of the districts of Telangana and Rayalaseema have low productivity levels coupled with high rainfall variability.Therefore, here productivity levels may have to be raised by encouraging the farmers to adopt suitable crops based on the availability of rain water and soil conditions.

This study was conducted in four districts of Andhra Pradesh and four districts of Telangana state, to understand the impact of climate change on agricultural productivity and GDP.At the mandal and district level, rainfall, temperature and its effect on productivity was analysed by taking climatic data for a period of 25 years.It is found that there was not much deviation in the maximum and minimum temperature in all the selected mandals of the districts during this period.For all the selected eight districts the co-efficient of variance (COV) were calculated, the highest and lowest COV values were taken in selecting the mandals for a detailed study.

The land-use / land-cover maps for the selected mandals were prepared, except for few mandals all the selected mandals showed high percentage of area under cropped land.
The study shows that significant changes have occurred in the rainfall patterns and this has also had its impact on the productivity of crops like Paddy, Chillies, Jowar and groundnut in the study area.

Climatic deviation has been amply evidenced in all the agroclimatic zones.The linear percentage deviation between the annual and normal rainfall in Telangana zones ranged between 48.0% to -42%.In coastal Andhra the range was between 69.0% to -48%, where as in Rayalseema selected districts, the range was between 60.0% to -45%.Overall it is observed that number of years below normal rainfall has been greater for the study period.Percentage deviation from normal is found to be higher in the districts of Krishna, Guntur, Kurnool and Ananthapur; but a contrasting trend has been observed in Warangal district where in 15 years (out of 25 years) showed rainfall below normal.

Average maximum temperature and minimum temperature have been correlated with Southwest and Northeast monsoon seasons for all the selected agroclimatic zones the

correlation values showed a positive impact excepting in a few cases in Mahabubnagar, Guntur, Ananthpur and Kurnool districts, where average maximum temperature showed negative correlation with Southwest monsoon season.This analysis brings forth the fact that temperature has a definite impact on rainfall variability.

The range of percentage deviation of rainfall from normal; for deficit years was between 19.6 to -6.1 in Telangana region, in coastal Andhra region it was -0.25% to -82.35% whereas in Rayalaseeema it was between -32.1% to -96.25%.

Regression coefficients here carried out for the selected thirty-eight mandals.As Rice is a major crop of the three regions a detailed analysis for kharif and rabi seasons was carried out and there was a high correlation values for both seasons.However. a few mandals of Warangal, Nalgonda and Khammam have showed low R^2 values. This indicates that climatic variability has a significant impact on productivity in scarce rainfall zone where as in wet zone i.e. Krishna and Guntur the impact is relatively less.

Ordinary least square model was used to confirm the impact of climate on agricultural productivity of Paddy, Groundnut, Cotton, Chillies, Maize, Redgrams.Impact of climate is less evidenced under the first data set i.e., prices, rainfall and production than the second data set which includes GDP.Hence it can be concluded that agricultural productivity and there by agricultural GDP are vulnerable to vagaries of climate.Further study also concludes that the impact of climate variability on crop production and agricultural GDP is significant for Groundnut, Chillies and Paddy in the Telangana and Rayalaseema districts. The negative results need to look into and addressed on priority and if current trends continue climate change could significantly have an impact on the crop productivity.
To ascertain the effect of climate change on agricultural productivity of Paddy, Chillies, Jowar and Groundnut crops multiple regression analysis was carried out and the analysis showed a direct impact of rainfall on the productivity of Groundnut and Jowar; and it is a mixed response for Paddy and Cotton.

The small and medium farmers were highly vulnerable to climatic change and to a larger extent the small and medium farmers have adopted coping mechanisms for climatic change compared to large farmers.The farmers already are tuned to the climatic changes both by adopting the technological coping mechanism on the positive side and negatively through shifting to other professions.

A Summary of the Findings: -

- The study aims at understanding the relation between meteorological parameters and agricultural productivity of the crops in the eight agroclimatic zones of the areas under study. Meteorological parameters contribute significantly towards the economic growth of the region.

- Land Use/ Land Cover maps for the selected mandals were prepared.

- Results of multiple regression analysis indicate that the variables of actual average rainfall, maximum and minimum temperature, fertilizers and human labor hours are around 13% to69% of variation in the productivity of paddy in the selected districts of Coastal Andhra, Rayalaseema and Telangana.

- The study concludes that the impact of climate variability on crop productivity and in turn on the GDP is significant in case of groundnut, chilly and paddy in the Telangana and Rayalaseema districts.

- It is concluded from the study that the negative results need to be addressed on a priority basis and if the current trend continues climate change would have significant adverse effects on crop productivity that needs to be altered with careful observation and altered farming practices.

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