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Climate change on crops in drought prone areas in Andhra Pradesh

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Abstract: *Droughts are the resultant of acute water shortage due to lack of rains over extended periods of time affecting various human activities and lead to problems like widespread crop failure, un replenished ground water resources, depletion in lakes/ reservoirs, shortage of drinking water and, reduced fodder availability etc. The drought prone areas in the country classified on annual rainfall departures fall either in arid, semi-arid and dry sub-humid regions where droughts occur frequently. As per the World Agriculture Census (WAC) 2010-11, in Andhra Pradesh 7.62 million farmers of which 86.29% are Small and Marginal Farmers. With more than 50% of unirrigated area under cultivation, agriculture continues to be monsoon dependant, primarily on South West Monsoon (SWM) through which State receives 2/3 of its rainfall. The State with 5 chronically drought prone districts (viz., Ananthapur, YSR Kadapa, Chittoor, Kurnool, and Prakasam) out of 13 districts. The country as a whole received 936.7 mm of rainfall against normal rainfall of 886.9 mm which represents a deviation of 6 percent above the Long Period Average (LPA). Out of 622 districts for which rainfall data were available, 184 districts (30 per cent) received excess rainfall, 264 districts (42 per cent) received normal rainfall, 156districts (25 per cent) received deficient rainfall and 18 districts (3%) received scanty rainfall. The present paper endeavours to examine the impact of climate change on crops in Kadapa District of Andhra Pradesh.*

Keywords: Climate Change, Drought, Rainfall, Crop Yield

Introduction

According to the National Academy of Sciences, Climate Change refers to any distinct change in measures of climate lasting for a long period of time. In other words, "climate change" means major changes in temperature, rainfall, snow, or wind patterns lasting for decades or longer. Climate change results from:

a) natural factors, such as changes in the Sun's energy or slow changes in the Earth's orbit around the Sun
b) natural processes within the climate system (e.g., changes in ocean circulation);
c) human activities that change the atmosphere's (e.g., burning fossil fuels) and the land surface (e.g., cutting down forests, planting trees, building developments in cities and suburbs, etc.)

In this paper, an attempt is made to study impact of climate change on crops in Kadapa District, Rayalaseema Region of Andhra Pradesh. Kadapa is Drought Prone Area, cultivation depends on monsoon which is erratic and the average annual rainfall in the district is 696.6 mm which is insufficient for cultivation. Out of 51 Mandals, nearly 38 Mandals considered as Drought Mandals. The data is collected from secondary sources i.e., Hand Book of Statistics, Chief Planning Officer, Kadapa and Revenue (Disaster Management) Department,

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Any remaining errors or omissions rest solely with the author(s) of this paper.

Govt. of Andhra Pradesh. The paper is organised into two sections: first part is focussing on Andhra Pradesh scenario and rest of the part is about study area i.e., Kadapa District.

Climate is the primary determinant of agricultural productivity. For example, crop and livestock yields are directly affected by changes in climatic factors such as temperature and precipitation and the frequency and severity of extreme events like droughts, floods, and wind storms. In addition, carbon dioxide is fundamental for plant production; rising concentrations have the potential to enhance the productivity of agro ecosystems. Climate change may also change the types, frequencies, and intensities of various crop and livestock pests; the availability and timing of irrigation water supplies; and the severity of soil erosion. (Richard M. Adams et al, 1998).

Climate change can influence agricultural production in a number of ways. One can roughly group the drivers into six categories (Mc Carl (2007) as follows:

- Temperature as it affects plants, animals, pests, and water supplies. For example, temperature alterations directly affect crop growth rates, livestock performance and appetite, pest incidence, and water supplies in soil and reservoirs.
- Precipitation as it alters, for example, the water directly available to crops, the drought-stress that crops are placed under, the supply of forage for animals, animal production conditions, irrigation water supplies, aquaculture production conditions, and river flows supporting barge transport.
- Changes in atmospheric CO2 as it influences the growth of crop plants and weeds by altering one of the basic inputs for photosynthesis.
- Extreme events as they influence production conditions destroy trees or crops, drown livestock, alter water supplies, and influence waterborne transport and ports.
- Sea level rise as it influences the suitability of ports and waterborne transport, inundates producing lands, and may alter aquaculture production conditions.
- Climate-change-motivated greenhouse gas net-emissions reduction efforts as they would influence the desirability of production processes and the costs of inputs, plus add new opportunities.

The Economic Perspective

As scientists have become more confident that greenhouse gases will lead to a rise in global temperatures (Houghton et al, 1996), developing countries have grown increasingly concerned about the economic impact of climate change on agriculture (Watson et al 1996).

Over time, humans have adapted agricultural systems and practices to changing economic and physical conditions. This has been accomplished by adopting new technologies (including investments in genetic improvements), changing crop mixes and cultivated acreages, and changing institutional arrangements. Such flexibility is suggestive of significant human potential to adapt to climate change (CAST 1992, Rosenberg 1992). For example, farm level adaptations can be made in planting and harvest dates, crop rotations, selection of crops and crop varieties for cultivation, water consumption for irrigation, use of fertilizers, and tillage practices. These adaptations are the natural consequence of producers' goals of maximizing returns to their land resource.

If climate uncertainty increases as the climate changes, adaptation responses will be affected. For example, if risk aversion is high among farmers in regions where water is limited, farmers may shift production from less to more drought-tolerant crops, even if expected returns are lower (Pope 1982, Dillon & Anderson 1990, Hurd 1994). The response of farmers to changes in climate events may differ in the future as a result of the uncertainty associated with regional and local climate change. In addition, adaptation may have unintended environmental consequences, e.g. the drive to increase production increases

environmental costs owing to increased pesticide use and increased use of marginal lands (Adams et al. 1988, Crosson & Anderson 1994).

To assess the likely effects of climate change, researchers have pursued three approaches: agronomic models, agro economic models, and Ricardian models. Rosenberg's (1992), paper employs a panel data methodology to show that the impact of climate change on Indian agriculture is likely to be negative over the short- to medium-term. The medium-term (2010-2039) impact on yields is estimated to be negative 4.5 to nine percent. Since agriculture makes up roughly 20 percent of India's GDP, this implies a cost of climate change of 1 to 1.8 percent of GDP per year over the medium run. Furthermore, agricultural productivity is particularly important for the well-being of the poor. The results of this paper pose two important questions for future research. First, what are the factors explaining the difference between these negative consequences for a developing country and the mildly positive results for the U.S. found by Deschens and Greenstone (2007)? Second, and crucial for the welfare of Indian agriculture, how quickly will developing country farmers be able to adjust their farming practices to adapt to the changing climate and what policies or technologies will enable rapid adaptation? Conspicuously, climate change is likely to reduce agricultural yields significantly, and that this damage could be severe unless adaptation to higher temperatures is rapid and complete.

Droughts, crop production and Rainfall

In certain vulnerable arid and semiarid regions, increased temperatures have already resulted in diminished precipitation. Notably, precipitation in Southern Asia and Western Africa has decreased by 7.5% between 1900 and 200525. Increased temperatures cause an intensification of the water cycle with more extreme variations in weather events and longer-lasting droughts. Furthermore, the expected temperature increase is likely to exacerbate drought conditions during sub-normal rainfall years. Large areas in Rajasthan, Andhra Pradesh, Gujarat, and Maharashtra and some areas of Karnataka, Orissa, Madhya Pradesh, Tamil Nadu, Bihar, West Bengal, and Uttar Pradesh are already experiencing recurrent drought with several regions currently experiencing water deficits.

The government has adopted a three pronged strategy to face droughts:

(1) providing relief to drought hit population under scarcity relief programmes
(2) Designing special area development programme for drought prone areas and desert prone area programme and DDP – desert development programme) and
(3) Promoting dry farming agriculture as a part of agricultural policy.

Somehow this approach has not worked very well, as is evident from the increasing drought prone areas in the country and the relatively high poverty and vulnerability of people living in these areas.

Andhra Pradesh scenario

As per the land use statistics 2010-11, the total geographical area of the country is 328.7 million hectares, of which 141.6 million hectares is the net sown area. The gross cropped area is 198.9 million hectares with a cropping intensity of 140.5%. The net irrigated area is 63.6 million hectares. The agriculture and allied sectors contributed approximately 13.9% of India's GDP (at constant 2004-05 prices) during 2013-14.

Andhra Pradesh State, annually producing about 140.27 Lakh Metric Tons of Food grains (2012-13), is an important State in Nation's Food Production. With about 49.38 Million Population, most of whom live in rural areas, agriculture is the main stay of their livelihood. 50.6 % of State's Main workforce is engaged in Agriculture & allied activities and Agriculture and allied Sectors accounts for 27.30 % of Gross State domestic product (GSDP) at current price. As per the World Agriculture Census (WAC) 2010-11, in Andhra Pradesh

7.62 million farmers of which 86.29% are Small and Marginal Farmers. With more than 50% of unirrigated area under cultivation, agriculture continues to be monsoon dependant, primarily on South West Monsoon (SWM) through which State receives 2/3 of its rainfall. The State with 5 chronically drought prone districts (viz., Ananthapur, YSR Kadapa, Chittoor, Kurnool, and Prakasam) out of 13 districts.

With two distinct geographical regions, Rayalaseema and Coastal Andhra, the State covers an area of 160,204 square KMs accounting for 4.87 %of total area in the country, Coastal Andhra 92,906 Sq KMs (58 % of State area) and Rayalaseema covering an area of 67,298 Sq KMs (42 % of State area).

Ananthapur revenue district is the largest district with an area of 19130 square KMs, followed by Kurnool (17600), Prakasam (17140), YSR Kadapa (15380), Chittoor (14990), SPS Nellore (13160), Visakhapatnam (11340), Guntur (11330), East Godavari (10820), Krishna (8800), West Godavari (7800), Vizianagaram (6300), Srikakulam (5840).

Net area sown (including Fish Ponds) during the year 2013-14 is 65.61 Lakh hectares (41.0 %of geographical area) As per Agriculture Census 2013-14, area under total Kharif crops is 54.06 lakh hectares.

Disruption of rainfall patterns

Andhra Pradesh receives an annual normal rainfall of 966 mms, of which 554 mms (57%) is received from South-West monsoon (June-Sept.), 298 mms (31%) is received from North-East monsoon (Oct.-Dec.) and remaining 12% is received during other months. The State receives major share of rainfall from South West Monsoon which begins in the first week of June and continues till the end of September. During South West Monsoon - 2014 (1-6-2014 to 30-09-2014), the State received a rainfall of 375.7 mm as against the normal rainfall of 554 mm with a deficit of (-) 32%. During last year for the corresponding period, the State received 514.1 mm with a deviation of (-) 7 %.

The State possesses two geographically distinct regions with significant diversity of natural resources, namely Rayalaseema region comprising **four** drought prone districts and predominant areas under rainfed cultivation and possessing rich mineral resources and Coastal Andhra spread along the coast line of Bay of Bengal consists of 9 districts with fertile soils and assured irrigation sources.

Table 1: Region-wise rainfall received during SWM, 2014.

Region	Actual	Normal	Dev (%)
Coastal Andhra	434.8	619.7	-29.8
Rayalaseema	242.8	406.6	-40.3
State	375.7	554.1	-32.2

Source: Revenue (Disaster Management) Dept. Govt. of Andhra Pradesh, 2015.

It is seen that Coastal Andhra received 434.8 mm as against 619.7 mm with a deficit of (-) 29.8 % and Rayalaseema received 242.8 mm as against the normal of 406.6 mm with a deficit of (-) 40.3 % District-wise Rainfall during SWM -2014 is given in Table – 1.2.

The below table 2 reveals that, Ananthapur District received the lowest rainfall of 172.9 mm in the State followed by SPS Nellore (207.9 mm), YSR Kadapa (213.1 mm), Prakasam (218.2 mm) Chittoor (271.5 mm), Guntur (309.2 mm), Kurnool (313.7 mm), East Godavari (418.4 mm), Krishna (421.9 mm), West Godavari (482.1 mm), Visakhapatnam (559.6 mm), Vizianagaram (625.5 mm) and Srikakulam (670.5 mm).

Table 2: District-wise Rainfall (in mm) during SWM-2014

S.no	District	SWM-2014		% Dev
		Actual	Normal	
1	Anantapur	172.9	338.4	-49
2	Nellore	207.9	331.3	-37
3	Kadapa	213.1	393.6	-46
4	Prakasam	218.2	388.3	-44
5	Chittoor	271.5	439.4	-38
6	Guntur	309.2	525.8	-41
7	Kurnool	313.7	455.1	-31
8	East Godavari	418.4	750.7	-44
9	Krishna	421.9	685.1	-38
10	West Godavari	482.1	785.0	-39
11	Visakhapatnam	559.6	712.6	-22
12	Viziyanagaram	625.5	692.7	-10
13	Srikakulam	670.5	705.7	-5
STATE AVERAGE		**375.7**	**554.1**	**-32**

Source: Revenue (Disaster Management) Dept. Govt. Of Andhra Pradesh, 2015

Impact on Crops

During the Season, due to non receipt of sufficient rainfall in the month of June, sowing of rainfed crops was delayed by nearly about 15 days to 30 days. In addition to this, crop growth was affected due to moisture stress due to insufficient rainfall leading to low yield of rainfed crops especially Groundnut and other crops like Jowar, Bajra, Ragi, Redgram, Cotton, Maize, Sunflower, including Paddy in Rayalaseema districts. Withered away of rainfed crops at the extent of 714678.29 Hectares in Ananthapur, Chittoor, YSR Kadapa and Prakasam Districts was also reported.

Table 3: Status of Drought affected District according to Rainfall

District	Month wise % of Deviation				
	June	July	August	September	SMW
Anantapur	-30	-47	-36	-70	-49
Kadapa	-38	-64	-38	-42	-46
Prakasam	-80	-9	-54	-43	-44
Guntur	-86	-32	-48	-16	-41
Nellore	-48	-54	-8	-42	-37
Kurnool	-36	-32	-17	-42	31

Source: Revenue (Disaster Management) Dept. Govt. Of Andhra Pradesh, 2015

Even though the normal sowing area covered during Kharif-2014 in above indicated Districts (Except Kadapa), due to deficit rainfall / uneven distribution of rainfall and Dry spells at critical stage of crops resulted in poor yields.

Drought

The International Panel on Climate Change (IPCC, 2009) indicates that rising temperatures, drought, floods, desertification and weather extremes will severely affect agriculture, especially in the developing World.

Table 4: Cropped Area falling under various ranges of Rainfall in India

Rainfall Ranges	Classification	%
Less than 750 mm	Low Rainfall	33
750 mm to 1125 mm	Medium Rainfall	35
1125 to 2000 mm	High Rainfall	24
Above 2000 mm	Very High Rainfall	8

Source: Drought 2002, A Report, Ministry of Agriculture, Govt of India

Large parts of the country perennially reel under recurring drought, over 68 % - 70 % of India is vulnerable to drought. 33 % classified as "chronically drought-prone areas", receives 750 mm of rainfall, while 35 % classified as "drought prone areas" receive rainfall of 750-1125 mm. The drought prone areas of the country are confined to peninsular and Western India primarily arid, semi-arid and sub-humid regions. In India, drought prone areas comprise a total land area of 329 million hectares, with three-fourths being arid, semi - arid and sub-humid areas

Table 5: Drought Affected Mandals in Andhra Pradesh

S.No.	District	No. of Mandals Eligible as Drought affected as per norms
	Anantapur	63
2	Chittoor	42
3	YSR Kadapa	48
4	Kurnool	12
5	Prakasam	54
6	SPSR Nellore	7
7	Guntur	4
Total		**230**

Source: Revenue (Disaster Management) Dept (2015), Govt. Of Andhra pradesh

An area of 25.10 lakh hectares against the normal Kharif area of 26.50 lakh hectares has been covered in affected 7 Districts during Kharif-2014. This constitutes 94.7 % of season normal area. District wise area sown is given below table 6. Due to Drought an extent of 289877 Ha was left unsown in the affected 7 Districts during Kharif-2014. The percentage of unsown area as proportion of total area sown is highest in YSR Kadapa (35.48%) followed by Ananthapur (19.30%), Prakasam (13.90%) etc.

Table 6: Area under Agriculture at District Level (Area in Ha).

District	Area under Irrigation	Normal Area Under Sowing	Total Area Sown	Total Area Unsown	Percentage 0f Unsown Area
Anantapur	66780	867564	700139	167425	19.30
Kadapa	**64387**	**179488**	**115808**	**63680**	**35.48**
Prakasam	109392	224630	193402	31228	13.90
Guntur	408701	517412	543485	0	0 0.00
Nellore	76915	87051	83540	3511	4.03
Kurnool	195609	558842	682086	0	0.00
Chittoor	48604	215358	191325	24033	11.16
Total	**970388**	**2650345**	**2509785**	**289877**	**10.94**

Source: Revenue (Disaster Management) Dept (2015), Govt. Of Andhra pradesh

Table 7: Rainfall Staus of Kadapa District 2008-15)

Season	Year													
	Normal Rainfall	**2014-15**		**2013-14**		**2012-13**		**2011-12**		**2010-11**		**2009-10**		**2008-09**	
		A	V%	A	V%	A	V%	A	V%	A	V%	A	V%	A	V%
South-West Monsoon (June-September)	393.6	211.0	-55.5	446.5	13.5	292.1	-26	374.6	-5	338.7	-14	330.6	-16	297.9	-24
North-East Monsoon (October-December)	251.0	111.7	-35.3	237.5	-5.4	209.6	-16	229.6	-9	94.5	-62	463.5	85	139.9	-44
Winter (January & February)	3.4	2.2	-35.3	0.0	-100.0	29.4	765	1.6	-53	2.7	-21	0.0	-100	0.0	-100
Summer (March-May)	51.6	8.8	137.8	24.7	-52.2	39.4	-24	59.3	15	58.7	14	79.9	55	77.2	50
Total	**699.6**	**333.7**	**-52.3**	**708.7**	**-1.3**	**570.5**	**-18**	**665.1**	**-5**	**494.6**	**-29**	**874.0**	**25**	**515.0**	**-26**

Source: Chief Planning Officer, 2015

Study Area

The Rayalaseema region covers in area about 67,293 sq.km. The region covers Anantapur, Chittoor, Kadapa and Kurnool districts Geographically the district is located in between 120 – 37' to 160 – 18'Northern latitudes, and 760 – 50' to 790 – 59' Eastern longitudes. The annual rainfall varies from 485 mm in Anantapur district to a maximum 1348 mm in Chittoor district. Climatologically the region experiences dry sub humid type of climate in major parts of the region.

Before going to discuss impact of climate change on crops it is necessary to know the background of the District. District is the extreme south eastern district of Andhra Pradesh situated within the geographical co-ordinate of 13043' and 15014' of northern latitude and 77055'and 79029' eastern longitude. The latitude varies from 269 to 3787 meters above sea level. The District is bounded on north by Kurnool District, on the south by Chittoor District on the west by Anantapur District and on the east by Nellore District. Total Geographical area of the District is 15,379 Sq.Kms. with 3 Revenue Divisions, 51 mandals, 790 Gram Panchayats, 972 Revenue Villages and 4954 Habitations.

The total geographical area of Y.S.R. District is 153,5,900 hectares which constitutes an extent of forest is 5,00,961 hectares, Barren & Uncultivable land is 2,22,099 hectares, Land put to Non-agricultural uses is 1,81,090 hectares, Cultivable Wast is 45,921 hectares, permanent pastures and other grazing lands is 9,409 hectares, land under miscellaneous tree crops & groves not included in net area sown is 6,831 hectares, current fallows is 1,31,767 hectares, other fallow land is 81,815 hectares, total cropped area is 4,25,113 hectares and net area sown is 3,56,007 hectares and area sown more than once is 69,106 hectares during the year 2012-13.

The Soils in the Kadapa District are of two types i.e., Red Ferruginous and Black Soils. Black Clay is the most superior soil in the District, which occupies 23.7 per cent area in the District. The District is rich in Minerals value. The Major Minerals in the District are Barites, Lime Stone and Asbestos. Apart from Major Minerals, Minor minerals are Napa Slabs, Road Metal, Building Stone, Marble, Mosaic Chips and Rehmatti are also in the District.

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

Table 8: Average Yields Per Hectare Of Principal Crops In Ysr District Yield In Kgs / Hectare

Sl. No.	Year	Paddy		Groundnut		Sunflower	
		Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
1	2005-2006	1884	2632	93	1837	433	712
2	2006-2007	2732	2194	268	2062	841	930
3	2007-2008	3060	2630	1897	1271	1279	1180
4	2008-2009	1737	2773	229	2158	1114	366
5	2009-2010	2933	2650	323	3145	1203	1109
6	2010-2011	1512	2870	608	2992	1097	227
7	2011-2012	2985	2649	330	2395	999	632
8	2012-2013	2549		252		209	

Source: Chief Planning Officer, YSR Kadapa.

Table 9: Crop-wise Area and Yield Area in Hec, Yield per Hec)

Crops	2009-10		2010-11		2011-12		2012-13		2013-14	
	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield
Rice	128194	2650	17037	2870	6606	2649	6601	2916	10959	3450
Jowar	4641	926	4185	1516	7881	333	12887	1446	6578	1284
Groundnut	19013	3145	17296	2992	20188	2395	20395	1567	17263	2620
Bengalgram	77338	493	77338	1105	90366	168	112194	168	97046	97046
Sesamum	6770	333	5763	352	4848	513	4729	572	9201	361
Sunflower	50711	1109	72977	227	60676	632	48021	401	26486	650

Source: Chief Planning Officer, 2014

Rain-fed agriculture faces several constraints such as high spatial variability, dependence on uncertain rain, fewer rainy days, over-exploitation of groundwater, impoverishment of soils and preponderance of the poor in arid and semi-arid terrains. Moreover, climate change is likely to accentuate the problem further. In the State of Andhra Pradesh, around 56 per cent of the net sown area is under rain-fed agriculture. Classifying a district as rain-fed if less than 30 per cent of its net sown area is not under dependable irrigation, the following districts qualify as rain-fed districts: Anantapur, Chittoor, Kadapa, Kurnool, Prakasam, Visakhapatnam and Vizianagaram. Of these, Anantapur is arid, Kadapa and Kurnool are semi-arid, Chittoor and Prakasam are wet semi-arid and Visakhapatnam and Vizianagaram are sub-humid. Droughts occur more frequently in arid, dry and semi-arid districts. Pulses are the major crop in the rain-fed as well as in irrigated districts. Groundnut is the predominant crop in the dry areas of Anantapur and Chittoor; chickpea in Kurnool and Prakasam. Black gram is the main crop in the dry areas of irrigated districts and cotton in Guntur. The percentage of cropped area under rain-fed crops has increased over time for cotton and maize at the cost of groundnut and sunflower (CESS Report, 2016).

Conclusions

Agriculture typically plays a larger role in developing economies than in the developed world. For example, agriculture in India makes up roughly 20% of GDP and provides nearly 52% of employment (as compared to 1% of GDP and 2% of employment for the US), with the majority of agricultural workers drawn from poorer segments of the population (FAO, 2006).

Spatial distribution and quantum of rainfall during South-West Monsoon (June-September) mainly determines the incidence of drought in the country, as South-West Monsoon accounts for more than 70% of annual rainfall. DAC closely monitors progress of South-West Monsoon in the country, in close coordination with India Meteorological Department (IMD) and keeps a watch over scanty/deficient rainfall conditions. State Governments initiate necessary relief measures in the wake of natural calamities including drought from State Disaster Response Fund (SDRF) which is readily available with them (Annual Report, 2013-14).

Long-term adaptation measures in the Agriculture sector include: changes in land use to maximise yield under new conditions; application of new technologies; new land management techniques; and water-use efficiency techniques. Reilly and Schummelpfenning (1999) define the following ‘major classes’ of adaptation, which include adapting to: seasonal changes and changing sowing dates and different varieties or species. Actions required may include those related to:

- water supply and irrigation systems;
- other inputs (fertiliser, tillage methods, grain drying, and other field operations);
- new crop varieties;

- forest fire management and/or other natural disasters.(UNFCCC,2007)

Furthermore, it is reasonable to expect that farmers in developing countries may be less able to adapt to climate change due to credit constraints or less access to adaptation technology. Water conservation and management practices, as well as water storage will need urgent attention. Kadapa is also considered to be one of the district endowed with rich history, of minerals flora & fauna.

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